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List of exhibits

6 Controls and visual indicators

This section contains human factors engineering rules for the design and selection of visual indicators and controls that are part of the human-equipment interfaces in FAA systems. Both general and specific design rules are provided for indicator-control integration and various types of controls.

6.1 Controls

This section contains rules for controls in general as well as for a wide variety of specific hand- and foot-operated controls. At times, the line between what is considered a control and what is considered an input device can be blurred, such as the use of pushbuttons in conjunction with trackballs in some systems and the use of knobs to adjust parameters (such as range) in other systems. Information on keyboards, trackballs, stylus pens, joysticks and mice contained in the section on input devices (Chapter 9).

6.1.1 General control information

6.1.1.1 Selection of controls

- **6.1.1.1.1 Distribution of workload.** Controls shall be selected and arranged so that none of a user's limbs is overburdened. [Source: Department of Defense (MIL-STD-1472F), 1999]

- **6.1.1.1.2 Multirotation controls.** Multirotation controls shall be used when precision is required over a wide range of adjustment. [Source: MIL-STD-1472F, 1999]

- **6.1.1.1.3 Detent stops.** Detent controls shall be selected whenever the operational mode requires control operation in discrete steps. [Source: MIL-STD-1472F, 1999]

- **6.1.1.1.4 Limit stops.** Stops shall be provided at the beginning and end of the range of control positions if the control is not to be operated beyond the indicated end positions or specified limits. [Source: MIL-STD-1472F, 1999]

□ **6.1.1.1.5 Characteristics of common controls.** The characteristics of different potential controls should be considered in the selection of a control for a given use. Characteristics of common controls for discrete adjustments are given in Exhibit 6.1.1.1.5 (a); characteristics of common controls for continuous adjustments are give in Exhibit 6.1.1.1.5 (b). [Source: Department of Energy (DOE-HFAC1), 1992]

Exhibit 6.1.1.1.5 (a) Characteristics of common controls for discrete adjustments

	Discrete adjustment				
Characteristics	**Rotary selector switch**	**Thumb-wheel**	**Hand push button**	**Foot push-button**	**Toggle switch**
Large forces can be developed	-	-	-	-	-
Time required to make control setting	Medium to quick	-	Very quick	Quick	Very quick
Recommended number of control positions (settings)	3 to 24	3 to 24	2	2	2 to 3
Space requirements for location and operation of control	Medium	Small	Small	Large	Small
Likelyhood of accidental activation	Low	Low	Medium	High	Medium
Desireable limits to control movement	270°	-	3mm x 30mm .13" x 1.5"	13 mm x 100mm .5" x4"	120°
Effectiveness of coding	Good	Poor	Fair to Good	Poor	Fair
Effectiveness of visually identifying control position	Fair to good	Good	Poor †	Poor	Fair to good
Effectiveness of nonvisually identifying control position	Fair to good	Poor	Fair	Poor	Good
Effectiveness of check-reading to determine control position when part of a group of like controls	Good	Good	Poor †	Poor	Good
Effectiveness of operating control simultaneously with like controls in an array	Poor	Good	Good	Poor	Good
Effectiveness as part of a combine control	Fair	Fair	Good	Poor	Good

† Exception: when control is back-lighted and light comes on when control is activated.

Exhibit 6.1.1.1.5 (b) Characteristics of common controls for continuous adjustments

	Continuous adjustment					
Characterisitcs	**Knob**	**Thumb-wheel**	**Hand wheel**	**Crank**	**Pedal**	**Lever**
Large forces can be developed	No	No	Yes	Yes	Yes	Yes
Time required to make control setting	-	-	-	-	-	-
Recommended number of control positions (settings)	-	-	-	-	-	-
Space requirements for location and operation of control	Small to medium	Small	Large	Medium to large	Large	Medium to large
Likelyhood of accidental activation	Medium	High	High	Medium	Medium	High
Desireable limits to control movement	Un-limited	180°	±60°	Un-limited	Small *	±45°
Effectiveness of coding	Good	Poor	Fair	Fair	Poor	Good
Effectiveness of visually identifying control position	Fair‡ to good	Poor	Poor to fair	Poor §	Poor	Fair to good
Effectiveness of nonvisually identifying control position	Poor to good	Poor	Poor to fair	Poor §	Poor to fair	Poor to fair
Effectiveness of check-reading to determine control position when part of a group of like controls	Good ‡	Poor	Poor	Poor §	Poor	Good
Effectiveness of operating control simultaneously with like controls in an array	Poor	Good	Poor	Poor	Poor	Good
Effectiveness as part of a combine control	Good ¶	Good	Good	Poor	Poor	Good

* Except for rotary which have unlimited range.
§ Assumes control makes more than one rotation.
‡ Applicable only when control makes less than one rotation. Round knobs must also have a pointer attached.
¶ Effective primarily when mounted concentrically on one axis with other knobs.

6.1.1.2 Direction of movement

- **6.1.1.2.1 Consistency of movement.** Movement of a control forward, clockwise, to the right, up, or pressing a control, shall turn the equipment or component on, cause the quantity to increase, or cause the equipment or component to move forward, clockwise, to the right, or up. [Source: MIL-STD-1472F, 1999]

  Discussion. Valve controls are exempt from this rule; their operation is specified in Paragraphs 6.1.1.2.2 and 6.1.1.2.3. [Source: MIL-STD-1472F, 1999]

- **6.1.1.2.2 Valve controls.** Rotary valve controls should open the valve with a counterclockwise motion. [Source: MIL-STD-1472F, 1999]

- **6.1.1.2.3 Labeling and marking valve controls.** Valve controls shall be provided with double-ended arrows showing the direction of operations and labeled at each end to indicate the functional result (e.g., open and close). [Source: MIL-STD-1472F, 1999]

6.1.1.3 Arrangement and grouping

- **6.1.1.3.1 Grouping controls.** Controls that are operated in a task-driven sequence or which are operated together shall be grouped together along with their associated displays. [Source: MIL-STD-1472F, 1999]

- **6.1.1.3.2 Arrangement by order of occurrence.** When several steps of a sequence are selected by one control, the steps shall be arranged by order of occurrence to minimize control movements and prevent cycling through unnecessary steps. Cycling through the control's ON/OFF position shall be avoided. [Source: MIL-STD-1472F, 1999]

- **6.1.1.3.3 Sequential operation.** Where sequential operations follow a fixed pattern, controls shall be arranged to facilitate operation (e.g., a left-to-right/top-to-bottom pattern, as on a printed page). [Source: MIL-STD-1472F, 1999]

- **6.1.1.3.4 Location of primary controls.** The most important and the most frequently used controls shall have the most favorable positions with respect to ease of seeing, reaching, and grasping (particularly rotary controls and those requiring fine settings). [Source: MIL-STD-1472F, 1999]

- **6.1.1.3.5 Consistency.** The arrangement of functionally similar, or identical, primary controls shall be consistent from panel to panel throughout a system or unit of equipment. [Source: MIL-STD-1472F, 1999]

- **6.1.1.3.6 Remote controls.** Controls, operated at a position remote from the display, equipment, or controlled vehicle, shall be arranged to facilitate direction-of-movement consistency. [Source: MIL-STD-1472F, 1999]

- **6.1.1.3.7 Controls for maintenance and adjustment.** In general, controls used solely for maintenance and adjustment shall be covered during normal equipment operation, but shall be readily accessible and visible to a user when required. [Source: MIL-STD-1472F, 1999]

- **6.1.1.3.8 Spacing.** Spacing between two controls of different types or between a single control and an obstruction shall be at least that specified in Exhibit 6.1.1.3.8. [Source: MIL-STD-1472F, 1999]

Exhibit 6.1.1.3.8 Minimum spacing between controls

	Toggle switches	* Push buttons	Continuous rotary controls	Rotary selector switches	Discrete thumbwheel controls
Toggle switches	See Exhibit 7.4.4.10.1	13 mm (0.5 in)	19 mm (0.75 in)	19 mm (0.75 in)	13 mm (0.5 in)
* Push buttons	13 mm (0.5 in)	See Exhibit 7.4.4.8.1	13 mm (0.5 in)	13 mm (0.5 in)	13 mm (0.5 in)
Continuous rotary controls	19 mm (0.75 in)	13 mm (0.5 in)	See exhibit 7.4.4.4.1	25 mm (1.0 in)	19 mm (0.75 in)
Rotary selector switches	19 mm (0.75 in)	13 mm (0.5 in)	25 mm (1.0 in)	See exhibit 7.4.4.1.1	19 mm (0.75 in)
Discrete thumbwheel	13 mm (0.5 in)	13 mm (0.5 in)	19 mm (0.75 in)	19 mm (0.75 in)	See exhibit 7.4.4.3.8

* For push buttons not separated by barriers.

Note. All values are for one hand operation. Distances are measured from edge of each control.

- **6.1.1.3.9 Spacing to accommodate hand wear.** Spacing shall be increased as appropriate to accommodate the wearing of gloves, mittens, or other protective hand wear. [Source: MIL-STD-1472F, 1999]

6.1.1.4 Coding

- **6.1.1.4.1 Methods and requirements.** The coding of controls for a particular application, for example, by size or color, shall be governed by the relative advantages and disadvantages of each type of coding as shown in Exhibit 6.1.1.4.1. [Source: MIL-STD-1472F, 1999]

Exhibit 6.1.1.4.1 Advantages and disadvantages of different types of coding

Advantages	Location	Shape	Size	Mode of operation	Labeling	Color
Improves visual identification	X	X	X		X	X
Improves nonvisual indentification (tactual and kinesthetic)	X	X	X	X		
Helps standardization	X	X	X	X	X	X
Aids identification under low levels of illumination and colored lighting	X	X	X	X	A	A
May aid in identifying control position (settings)		X		X	X	
Requires little (if any) training; is not subject to forgiving					X	
Disadvantages						
May require extra space	X	X	X	X	X	
Affects manipulation of the control (ease of use)	X	X	X	X		
Limited number of available coding categories	X	X	X	X		X
May be less effective if operator wears gloves		X	X	X		
Controls must be viewed (for example, must be within visual areas and with adequate illumination present)					X	X

Note:
A - When transilluminated

- **6.1.1.4.2 Coding to differentiate.** Where coding is used to differentiate among controls, application of the code shall be uniform throughout the system. [Source: MIL-STD-1472F, 1999]

- **6.1.1.4.3 Location coding.** Controls associated with similar functions should be in the same relative location from work station to work station and from panel to panel. [Source: MIL-STD-1472F, 1999]

- **6.1.1.4.4 Size coding.** No more than three different sizes shall be used to code controls for discrimination by absolute size. [Source: MIL-STD-1472F, 1999]

- **6.1.1.4.5 Consistent size coding.** Controls used for performing the same function on different items of equipment shall be the same size. [Source: MIL-STD-1472F, 1999]

- **6.1.1.4.6 Knob diameter as the coding parameter.** When knob diameter is used as the coding parameter, the differences between diameters shall be not less than 13 mm (0.5 in). [Source: MIL-STD-1472F, 1999]

- **6.1.1.4.7 Knob thickness as the coding parameter.** When knob thickness is the coding parameter, the differences between thickness shall be not less than 10 mm (0.4 in). [Source: MIL-STD-1472F, 1999]

- **6.1.1.4.8 Shape-coding.** When shape-coding is used

  a. the coded feature shall not interfere with ease of control manipulation.

  b. shapes shall be identifiable by hand and by eye regardless of the position and orientation of the control knob or handle.

  c. shapes shall be tactually identifiable when gloves must be worn.

  d. the number of shapes to be identified by each operator based on absolute discrimination shall be not more than 10.

  e. shape-coded knobs and handles shall be positively and non-reversibly attached to their shafts to preclude incorrect attachment when replacement is required.

  f. shapes shall be associated with or resemble the control function, and not alternate functions. [Source: MIL-STD-1472F, 1999]

  Discussion. Shape-coding may be used to ensure identification of control knobs or handles by "feel" where visual identification is not possible, diversion of operator visual attention to identify the proper control would detract from mission accomplishment, or where the consequences of incorrect control selection would be severe.

- **6.1.1.4.9 Control colors.** Controls should be black (17038, 27038, or 37038) or gray (26231 or 36231). [Source: MIL-STD-1472F, 1999]

- **6.1.1.4.10 Color-coding of controls.** When color-coding is required, only the following colors identified in FED-STD-595 should be selected for control coding:

  a. Red, 11105, 21105, 31105

  b. Green, 14187

  c. Orange-Yellow, 13538, 23538, 33538

  d. White, 17875, 27875, 37875

  e. Blue, 15123 should be used if an additional color is absolutely necessary. [Source: MIL-STD-1472F, 1999]

- **6.1.1.4.11 Association of control with visual indicator.** When color-coding must be used to relate a control to its corresponding display, the same color shall be used for both the control and the display. [Source: MIL-STD-1472F, 1999]

- **6.1.1.4.12 Control panel contrast.** Sufficient color/brightness contrast between the control and its background shall be provided to ensure prompt and accurate identification by the operator. [Source: MIL-STD-1472F, 1999]

- **6.1.1.4.13 Ambient lighting and limitations on color-coding.** Color-coding shall be compatible with anticipated ambient light during the mission. [Source: MIL-STD-1472F, 1999]

- **6.1.1.4.14 Alternative primary coding.** Color-coding shall not be used as the primary identification medium if the spectral characteristics of such ambient light or the operator's adaptation to that light varies as the result of such factors as solar glare, filtration of light, and variation from natural to artificial light. [Source: MIL-STD-1472F, 1999]

- **6.1.1.4.15 Alternatives to red lighting.** If red lighting is to be used during a portion of the mission, controls that would otherwise be coded red shall be coded by orange-yellow and black striping. [Source: MIL-STD-1472F, 1999]

6.1.1.5 Compatibility with hand wear and blind operation

- **6.1.1.5.1 Compatibility with hand wear.** Controls shall be compatible with hand wear to be utilized in the anticipated environment. [Source: MIL-STD-1472F, 1999]

  Discussion. Unless otherwise specified, all dimensions cited herein are for bare hands and need to be adjusted where necessary for use with gloves or mittens. [Source: MIL-STD-1472F, 1999]

- **6.1.1.5.2 Use of prototypes.** . When the use of hand wear is anticipated, the compatibility of a control with the hand wear should be evaluated through the use of prototypes. [Source: DOE-HFAC1, 1992]

- **6.1.1.5.3** "**Blind" operation.** Where "blind" operation is necessary, hand controls shall be shape-coded, or separated from adjacent controls by at least 125 mm (5 in). [Source: MIL-STD-1472F, 1999]

6.1.1.6 Prevention of accidental actuation

- **6.1.1.6.1 Location and design.** Controls shall be designed and located so that they are not susceptible to being moved accidentally or inadvertently, particularly critical controls where such operation might cause equipment damage, personnel injury, or system performance degradation. [Source: MIL-STD-1472F, 1999]

- **6.1.1.6.2 Internal controls**. Internal or hidden controls should be protected from inadvertent actuation or movement, because it is usually not obvious that such controls have been disturbed and it may be difficult and time consuming to locate and readjust them. [Source: MIL-STD-1472F, 1999]

- **6.1.1.6.3 Rapid operation.** Any method of protecting a control from inadvertent operation shall not preclude operation within the time required. [Source: MIL-STD-1472F, 1999]

- **6.1.1.6.4 Methods.** If a control must be protected from accidental actuation, one or more of the following methods shall be used:

  a. Locate and orient the control so that a user is not likely to strike or move it accidentally in the normal sequence of control movements.

  b. Recess, shield, or otherwise surround the control with a physical barrier. The control shall be entirely contained within the recess or barrier envelope.

  c. Cover or guard the control, but without using safety or lock wire.

  d. Interlock the control so that extra movement (e.g., a side movement out of a detent position or a pull-to-engage clutch) or the prior operation of a related or locking control is required.

  e. Provide the control with resistance, such as viscous or coulomb friction, spring loading, or inertia, so that definite or sustained effort is required for actuation.

  f. Lock the control to prevent its quickly passing through a position when strict sequential activation is necessary (i.e., the control is moved only to the next position, then delayed).

  g. Design the control for operation by rotary action. [Source: MIL-STD-1472F, 1999]

- **6.1.1.6.5 "Dead man" controls.** "Dead man" controls, which will result in system shut-down to a non-critical operating state when force or input is removed, shall be utilized wherever operator incapacity can produce a critical system condition. [Source: MIL-STD-1472F, 1999]

6.1.2 Labeling and marking controls

Design rules for labels, markings, and colors for controls are given in this section. In this section, the term "label" is intended to include legends, placards, signs, and markings.

6.1.2.1 General

Label characteristics need to be consistent with requirements for accuracy of identification, time available for recognition or other responses, distance at which the labels must be read, illumination level and color, criticality of the function labeled, and label design within and among controls and systems. [Source: MIL-STD-1472F, 1999]

- **6.1.2.1.1 Use.** Labels shall be provided whenever it is necessary for users: (1) to locate and identify controls (2) to interpret and follow procedures, or (3) to avoid hazards. [Source: MIL-STD-1472F, 1999]

- **6.1.2.1.2 Size graduation.** To reduce confusion and operator search time, labels shall be graduated in size. [Source: MIL-STD-1472F, 1999]

- **6.1.2.1.3 Character size on group labels.** The characters in group labels shall be larger than those used to identify individual controls and displays. [Source: MIL-STD-1472F, 1999]

- **6.1.2.1.4 Character size for controls and displays.** The characters identifying controls and displays shall be larger than the characters identifying control positions. [Source: MIL-STD-1472F, 1999]

- **6.1.2.1.5 Determination of smallest character size.** With the smallest characters determined by viewing conditions, the dimensions of each character shall be at least approximately 25 % larger than those of the next smaller label. [Source: MIL-STD-1472F, 1999]

- **6.1.2.1.6 Demarcation with size graduation.** To best apply size graduation, the components should be functionally grouped and demarcated or spaced to reveal system and subsystem groupings. [Source: Electric Power Research Institute (EPRI NP 6209), 1988]

- **6.1.2.1.7 General requirements.** Controls and displays shall be appropriately and clearly labeled with the basic information needed for proper identification, utilization, actuation, or manipulation of the element. [Source: MIL-STD-1472F, 1999]

- **6.1.2.1.8 Principles of labeling.** Labels shall

  a. give the user relevant information needed to perform his or her task (for example, make or model of equipment)

  b. be supplemented where appropriate with other coding such as color and shape (as in warning or danger signs,

  c. use only boldface type to emphasize words or phrases, and

  d. if appropriate, be etched or embossed into the surface for durability, rather than stamped, stenciled, or printed. [Source: Department of Defense (MIL-HDBK-759B), 1992]

- **6.1.2.1.9 Avoid similar labels.** Similar names for different controls shall be avoided. [Source: MIL-STD-1472F, 1999]

- **6.1.2.1.10 Meaningful labels.** Controls shall be labeled in terms of what is being measured or controlled, taking into account the user as well as the purpose of the control or visual indicator. [Source: MIL-STD-1472F, 1999]

- **6.1.2.1.11 Function labels.** The labels for controls shall indicate the functional result of control movement such as increase, ON, and OFF and include calibration data where applicable and be visible during normal operation of the control. [Source: MIL-STD-1472F, 1999]

- **6.1.2.1.12 Functional relationship.** When controls and displays must be used together to make adjustments, appropriate labels shall indicate their functional relationship. [Source: MIL-STD-1472F, 1999]

- **6.1.2.1.13 Functional relationship.** Terminology used on control labels shall be consistent. [Source: MIL-STD-1472F, 1999]

- **6.1.2.1.14 Label mounting.** Labels that are not part of the equipment or component shall be securely attached to prevent their loss, damage, slippage, or accidental removal and attached to a structural member that is not removed during equipment servicing or routine maintenance. [Source: MIL-STD-1472F, 1999]

- **6.1.2.1.15 Label removal.** Users should be able to remove a label without damaging the surface to which it was attached. [Source: EPRI NP 6209]

- **6.1.2.1.16 Curved labels.** Curved labels (for example, a label that is wrapped around a pipe or cable) shall be avoided. [Source: MIL-STD-1472F, 1999]

- **6.1.2.1.17 Label reflectance.** Labels shall be constructed of non-reflective materials to avoid illegibility due to a light source being reflected back to the viewer. [Source: EPRI NP 6209]

- **6.1.2.1.18 Tag mounting.** When tags are used, they should be attached securely to equipment components by means of durable stranded stainless steel cable, clamps, or chains. [Source: EPRI NP 6209]

- **6.1.2.1.19 Non-interference of tag.** The length of the cable, clamp, or chain should be minimal so that the tag will not interfere with the operation or maintenance of the equipment. [Source: EPRI NP 6209]

6.1.2.2 Location and orientation

- **6.1.2.2.1 Readability.** Control labels shall be located so that they are visible and readable with the control in its installed position. [Source: MIL-STD-1472F, 1999]

- **6.1.2.2.2 No obstruction.** Labels shall not be located where they obscure other information needed by the user or where a control or user's normal hand or arm position will obscure the label. [Source: MIL-STD-1472F, 1999]

- **6.1.2.2.3 Position near control or visual indicator.** Labels shall be placed very near the control that they identify. [Source: MIL-STD-1472F, 1999]

- **6.1.2.2.4 Above control or visual indicator.** Labels should normally be placed above the control they describe, or when located above eye level, may be located below the control if label visibility will be enhanced. [Source: MIL-STD-1472F, 1999]

- **6.1.2.2.5 Separate labels.** Adjacent labels should be separated by sufficient space so they are not read as one continuous label. [Source: MIL-STD-1472F, 1999]

- **6.1.2.2.6 Functional grouping.** Labels shall be used to identify functionally grouped controls. [Source: MIL-STD-1472F, 1999]

- **6.1.2.2.7 Line enclosing a grouping.** When a line is used to enclose a functional group and define its boundaries, the label shall be centered at the top of the group either in a break in the line or just below the line. [Source: MIL-STD-1472F, 1999]

- **6.1.2.2.8 Colored areas.** When colored areas are used and sufficient space is available, the label shall be centered at the top within the area. [Source: MIL-STD-1472F, 1999]

- **6.1.2.2.9 Functional grouping.** When there is insufficient room for the label to be centered in the enclosed or colored area, it shall be located in the best available space provided the grouping is demarcated. [Source: MIL-STD-1472F, 1999]

- **6.1.2.2.10 Label highlighted.** The summary label should be bordered or otherwise highlighted to make it stand out. [Source: MIL-STD-1472F, 1999]

- **6.1.2.2.11 Consistent location.** Labels should be located consistently throughout the system. [Source: MIL-STD-1472F, 1999]

- **6.1.2.2.12 Hierarchical labeling.** A hierarchical labeling scheme should be used on panels to reduce confusion and search time based on the following:

  a. Use major labels to identify major systems or user workstations.

  b. Use subordinate or group labels to identify subsystem or functional groups.

  c. Use component labels to identify each panel or console element.

  d. Do not repeat information contained in higher-level labels in lower level labels. [Source: MIL-STD-1472F, 1999]

- **6.1.2.2.13 Horizontal orientation.** Labels shall be oriented so that alphanumeric characters are read horizontally from left to right. [Source: MIL-STD-1472F, 1999]

- **6.1.2.2.14 Vertical orientation.** Vertical orientation should be used only when labels are not critical for personnel safety or performance and where space is limited. When used, vertical labels should read from top to bottom. [Source: MIL-STD-1472F, 1999]

- **6.1.2.2.15 Preserving readability.** Labels shall be mounted so as to minimize wear or obscuration by grease, grime, or dirt, and shall remain legible for the overhaul interval of the labeled equipment. [Source: MIL-STD-1472F, 1999]

6.1.2.3 Design of label characters

- **6.1.2.3.1 Character height for viewing distance.** Unless circumstances require otherwise, labels shall be clearly legible at a viewing distance of 710 mm (28 in). The recommended height for letters and numerals at this distance is approximately 5 mm (0.18 in). Exhibit 6.1.2.3.1 gives minimum character heights for other viewing distances. [Source: Department of Energy (UCRL-15673), 1985]

Exhibit 6.1.2.3.1 Minimum character height for various viewing distances under normal luminance levels

Viewing distance	Minimum height
Less than 0.5 m (20 in)	2.3 mm (0.1 in)
0.5 - 1.0 m (20 - 40 in)	4.7 mm (0.2 in)
1.0 - 2.0 m (40 - 80 in)	9.4 mm (0.4 in)
2.0 - 4.0 m (80 - 160 in)	18 mm (0.75 in)
4.0 - 9.0 m (13 - 30 ft)	38 mm (1.5 in)

- **6.1.2.3.2 Stroke width in normal illumination.** If labels are expected to be read under normal illumination, characters shall be black on a white or light background, and stroke width shall be 1/6 to 1/7 of the height [Source: MIL-STD-1472F, 1999]

- **6.1.2.3.3 Stroke width in dim illumination.** Where dark adaptation is required or legibility at night is a critical factor, and white characters are specified on a dark background, the stroke width of the characters shall be from 1/7 to 1/8 of the height. [Source: MIL-STD-1472F, 1999]

- **6.1.2.3.4 Consistent stroke width.** The stroke width shall be the same for all letters and numerals of equal height. [Source: MIL-STD-1472F, 1999]

- **6.1.2.3.5 Stroke width for transilluminated characters.** For transilluminated characters, the stroke width shall be 1/10 of the height. [Source: MIL-STD-1472F, 1999]

- **6.1.2.3.6 Width to height ratios.** The width-to-height ratio of letters and numerals shall be 4:5 for "M" and "W," one stroke width wider for "4," one stroke wide for "I" and "1," and 3:5 all other letters and numerals. [Source: MIL-STD-1472F, 1999]

- **6.1.2.3.7 Character spacing.** The minimum space between characters shall be one stroke width. [Source: MIL-STD-1472F, 1999]

- **6.1.2.3.8 Word spacing.** The spacing between words shall be approximately the width of one normal-width character. [Source: MIL-STD-1472F, 1999]

- **6.1.2.3.9 Line spacing.** The minimum space between lines shall be approximately one-half the character height. [Source: MIL-STD-1472F, 1999]

- **6.1.2.3.10 Case of letters for single word labels.** When the text on a label is exclusively single words, such as names, the words shall appear as all capital letters. [Source: MIL-STD-1472F, 1999]

- **6.1.2.3.11 Case of letters for multiple words labels.** When the text on a label are phrases or sentences, the text shall appear as mixed case letters. [Source: MIL-STD-1472F, 1999]

- **6.1.2.3.12 Contrast.** When the ambient illumination will be above 10 lux (0.9 ft-c), dark characters on a light background shall be used. [Source: MIL-STD-1472F, 1999]

  Discussion. Black letters on a white background offer the best contrast. Good contrast is also provided by black on yellow, dark blue on white, dark green on white, and dark red on white. [Source: MIL-STD-1472F, 1999]

- **6.1.2.3.13 Non-interfering dark adaptation.** When dark adaptation is required, the visually indicated alphanumeric characters shall be visible without interfering with night vision requirements. [Source: MIL-STD-1472F, 1999]

- **6.1.2.3.14 Marking characteristics for dark adaptation.** When dark adaptation is required, markings should be white on a dark background. [Source: MIL-STD-1472F, 1999]

- **6.1.2.3.15 Style or font.** A simple font without serifs should be selected. [Source: Nuclear Regulatory Commission (NUREG-0700), 1981; EPRI NP 6209]

- **6.1.2.3.16 Confusion between characters.** When a label contains pairs of characters that might be confused, the following applies.

  a. The lower case letter "l" should have a short extension at the bottom extending to the right.

  b. The numeral "1" should have a short extension at the top extending to the left.

  c. The numeral "0" should appear narrower than the letter "O" of a given font. [Source: MIL-HDBK-759B, 1992]

- **6.1.2.3.17 Borders.** Space should be provided between characters and words to prevent the label from appearing crowded or difficult to read with a minimum clearance around a character or word of 1/2 character height or more. [Source: MIL-HDBK-759B, 1992]

  Discussion. However, clearance around a character, a word, or a set of words should not make the label appear "lost" within a large expanse of background. [Source: MIL-HDBK-759B, 1992]

6.1.2.4 Wording and information

- **6.1.2.4.1 Wording.** Labels should be unambiguous and as concise as possible without distorting the intended meaning or information. [Source: MIL-STD-1472F, 1999]

- **6.1.2.4.2 Minimize redundancy.** Redundancy should be minimized. [Source: MIL-STD-1472F, 1999]

- **6.1.2.4.3 Identify specific function.** Where a general function is obvious, only the specific function should be identified (e.g., “rpm” rather than “engine rpm”). [Source: MIL-STD-1472F, 1999]

- **6.1.2.4.4 Simplicity.** Control labels shall convey verbal meaning in the most direct manner by using simple words and phrases. [Source: DOE-HFAC1, 1992, MIL-STD-1472F, 1999]

- **6.1.2.4.5 Abbreviations.** Abbreviations should be used in labels only if they are familiar to the users and users, for example, psi and km. [Source: DOE-HFAC1, 1992, MIL-STD-1472F, 1999]

- **6.1.2.4.6 Consistency.** Designations and terms used on labels shall be consistent with designations and terms in user documentation and parts catalogs. [Source: UCRL-15673, 1985]

- **6.1.2.4.7 Irrelevant information.** Trade names and other irrelevant information shall not appear on labels. [Source: MIL-STD-1472F, 1999]

- **6.1.2.4.8 Relevant information.** Labels shall be provided whenever personnel must identify, interpret, or follow procedures or avoid hazards. [Source: MIL-STD-1472F, 1999]

- **6.1.2.4.9 Pictorial symbols.** When pictorial symbols are used in place of or in addition to word labels, they shall be completely unambiguous in the expected visual operating environment, and not be used on a control that may rotate and thus position the symbol so that it may be confusing. [Source: MIL-HDBK-759B, 1992]

6.1.3 Foot-operated controls

- **6.1.3.1 When to use.** Foot-operated controls should be used under the following conditions:

  a. A control operation requires either greater force than the upper body can produce or a force close to the upper body fatigue threshold.

  b. The user's hands are expected to be occupied with other manual control tasks at the time an additional control action is needed.

  c. A specific foot-operated control has been so well established that a user would expect it, for example, aircraft rudder and brake pedals and automotive clutch, brake, and accelerator pedals.

  d. A safety "shutdown" control is needed during an operation in which the user's hands cannot be freed to reach a safety switch. [Source: MIL-STD-1472F, 1999]

- **6.1.3.2 When not to use.** Foot-operated controls should not be used under the following conditions:

  a. A standing user is confronted with a sensitive balancing requirement, such as a moving platform, that would make it difficult to balance on one foot while operating the control with the other.

  b. A precise control action is required.

  c. Selection from many controls is required. [Source: MIL-STD-1472F, 1999]

- **6.1.3.3 Location of foot controls.** Foot controls shall be located and designed so that they can be operated in as natural a way as practicable. [Source: MIL-STD-1472F, 1999]

- **6.1.3.4 What to avoid.** The following shall be avoided in the design of foot operated controls:

  a. frequent, maximum reaching,

  b. requiring that the leg or foot be held in an awkward position for extended periods of time,

  c. requiring that a user operate a control frequently or for an extended period of time while sitting in an awkward or uncomfortable position,

  d. requiring frequent or prolonged application of maximum force,

  e. requiring that a user search for a particular foot control in order to select the proper one, and

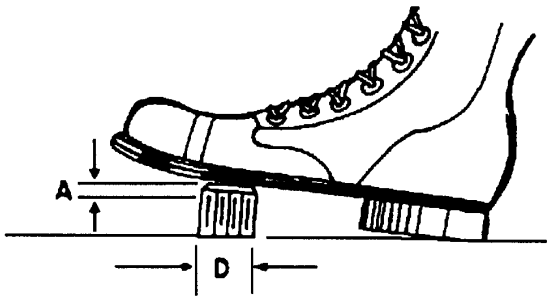
  f. placing a foot control where it might be stepped on and actuated inadvertently or where typical movement from one foot control to another creates conditions in which the foot or clothing might be entrapped by an intervening control as a user moves the foot from one control to another. [Source: MIL-STD-1472F, 1999]

- **6.1.3.5 Configuration and placement.** Configuration and placement of foot-operated controls shall accommodate the anthropometry of the operator's foot wearing operational shoes or boots with each foot-operated control located so that (a) actuating it by one foot does not interfere with actuating a control by the other foot and (b) foot and leg movements are natural and easily accomplished within the work station where the foot controls are located. [Source: MIL-STD-1472F, 1999]

6.1.4 Foot-operated switches

- **6.1.4.1 Foot-operated switch dimensions.** The dimensions, resistance, and displacement of foot-operated switches shall not exceed the maximum and minimum values given in Exhibit 6.1.4.1. [Source: MIL-STD-1472F, 1999]

Exhibit 6.1.4.1 Foot-operated switch specifications



	Diameter	Resistance		Displacement			
	D			A			
		Foot will not rest on control	Foot will rest on control	Normal operation	Heavy boot operation	Ankle flexion only	Total leg movement
Minimum	13 mm (0.5 in)	18 N (4 lb)	45 N (10 lb)	13 mm (0.5 in)	25 mm (1 in)	25 mm (1 in)	25 mm (1 in)
Maximum	-	90 N (20 lb)	90 N (20 lb)	65 mm (2.5 in)	65 mm (2.5 in)	65 mm (2.5 in)	100 mm (4 in)

- **6.1.4.2 Multiple foot-operated switch separation.** Although only one switch per foot is recommended, when it is necessary that more than one switch be operated by the same foot, those switches shall be separated by at least 75 mm (3.0 in) horizontally and 200 mm (8.0 in) vertically. [Source: MIL-STD-1472F, 1999]

- **6.1.4.3 When to use.** Foot-operated switches should be used only where the operator is likely to have both hands occupied when switch actuation may be required, or when load sharing among limbs is desirable. [Source: MIL-STD-1472F, 1999]

  Discussion. Because foot-operated switches are susceptible to accidental actuation, limit their use to non-critical or infrequent operations such as press-to-talk communication or vehicle headlight dimming. [Source: MIL-STD-1472F, 1999]

- **6.1.4.4 Operation.** Foot switches shall be positioned for operation by the toe and ball of the foot rather than by the heel. [Source: MIL-STD-1472F, 1999]

- **6.1.4.5 Obstruction free placement.** They shall not be located near an obstruction that would prevent a user from centering the ball of the foot on the switch button. [Source: MIL-STD-1472F, 1999]

  Discussion. A pedal may be used over the button to aid in locating and operating the switch. [Source: MIL-STD-1472F, 1999]

- **6.1.4.6 Operation in wet or slippery conditions** When the switch may become wet and slippery, the switch cap surface should provide a high degree of frictional resistance. [Source: MIL-STD-1472F, 1999]

- **6.1.4.7 Feedback.** A positive indication of control actuation shall be provided (e.g., snap feel, audible click, or associated visual or audio display). [Source: MIL-STD-1472F, 1999]

6.1.5 Hand-operated controls

6.1.5.1 Rotary selector switches

- **6.1.5.1.1 Rotary selector switch specifications.** The dimensions, resistance, displacement, and separation between adjacent edges of areas swept by rotary selector switches should not exceed the maximum and minimum values given in Exhibit 6.1.5.1.5. [Source: MIL-STD-1472F, 1999]

- **6.1.5.1.2 When to use.** When a switch must have three or more detented positions, a rotary selector switch should be used. [Source: MIL-STD-1472F, 1999]

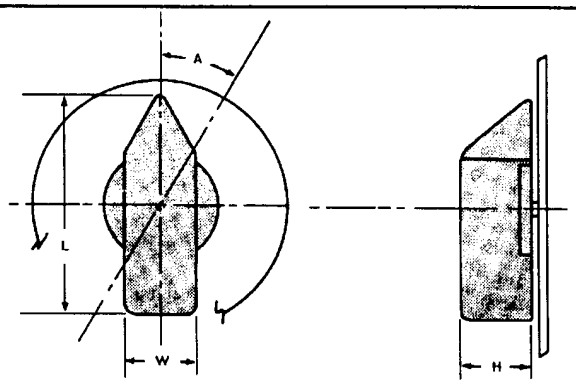
- **6.1.5.1.3 Two detented positions.** When only two detented positions are needed, a rotary switch should not be used unless prompt visual identification of the switch position is of prime importance, and speed of control operation is not critical. [Source: MIL-STD-1472F, 1999]

- **6.1.5.1.4 Moving pointer, fixed scale.** Rotary selector switches should have moving pointers and fixed scales. [Source: MIL-STD-1472F, 1999]

■ **6.1.5.1.5 Shape.** Moving pointer knobs shall be bar-shaped, with parallel sides and with the indicating end tapered to a point, as illustrated in Exhibit 6.1.5.1.5. [Source: MIL-STD-1472F, 1999]

Exception. Exceptions may be justified if pointer knobs are shape coded or if space is restricted and torque is light. [Source: MIL-STD-1472F, 1999]

Exhibit 6.1.5.1.5 Rotary selector switch



Dimensions

	Length L	Width W	Height H	Resistance
Minimum	25 mm (1 in)	--	16 mm (0.6 in)	115 mN*m (1 in*lb)
Maximum	100 mm (4 in)	25 mm (1 in)	75 mm (3 in)	680 mN*m (6 in*lb)

	Displacement A		Separation	
	†	‡	One-hand random	Two-hand operation
Minimum	15°	30°	25 mm (1 in)	75 mm (3 in)
Maximum	40°	90°	--	--
Preferred	--	--	50 mm (2 in)	125 mm (5 in)

† For facility performance

‡ When special engineering requirements demand large separation or when tactually ("blind") positioned controls are required.

- **6.1.5.1.6 Shape coding.** Shape coding shall be used if a number of rotary controls located on the same panel and used for different functions might otherwise be confused. [Source: MIL-STD-1472F, 1999]

- **6.1.5.1.7 Reference line.** A rotary switch control shall have an associated reference line. This line shall have a luminance contrast of at least 3.0 with the color of the switch control under all lighting conditions. [Source: MIL-STD-1472F, 1999]

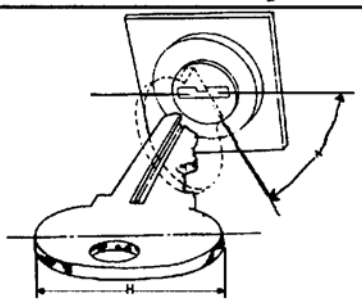
- **6.1.5.1.8 Parallax.** The knob pointer shall be mounted sufficiently close to its scale to minimize parallax between the pointer and scale markings. When viewed from the user's normal working position, parallax errors shall not exceed 25 % of the distance between scale markings. [Source: MIL-STD-1472F, 1999]

6.1.5.2 Key-operated switches

Key-operated switches are used to prevent unauthorized operation. Ordinarily, they provide ON and OFF system operation.

- **6.1.5.2.1 Key-operated switch specifications.** The dimensions, displacement, and resistance shall not exceed the maximum and minimum values given in Exhibit 6.1.5.2.1. [Source: MIL-STD-1472F, 1999]

Exhibit 6.1.5.2.1 Key-operated switch specifications



	Displacement (A)	Height (H)	Resistance
Minimum	30°	13 mm (0.5 in)	115 mN*m (1 in*lb)
Maximum	90°	75 mm (3 in)	680 mN*m (6 in*lb)

- **6.1.5.2.2 Color, shape, and size coding.** Use color, shape, or size coding or a combination according to the following:

  a. Color shall be used to aid in identifying various keys by function or use.

  b. Red shall be reserved for emergency functions.

  c. Color-coding shall be used only if ambient illumination is adequate to differentiate the colors.

  d. Shape-coding may be used when it is desirable to identify a given key by feel.

  e. When shape coding is used, sharp corners shall be avoided.

  f. Size-coding shall also be used if no more than two sizes are employed and the sizes range from a minimum height of 13mm (0.5 in) to a maximum height of 75mm (3 in.) [Source: MIL-STD-1472F, 1999].

- **6.1.5.2.3 Marking and labeling.** Key-operated switches shall be appropriately marked and labeled. [Source: MIL-STD-1472F, 1999]

- **6.1.5.2.4 Teeth on both edges.** Keys for key-operated switches shall have teeth on both edges and shall fit the lock with either side up or forward. [Source: MIL-STD-1472F, 1999]

- **6.1.5.2.5 Teeth on a single edge.** When Paragraph 6.1.5.2.4 has been waived and keys with a single row of teeth are used, the lock shall be positioned so that the teeth point up or forward. [Source: MIL-STD-1472F, 1999]

- **6.1.5.2.6 ON-OFF switches.** Key-operated ON-OFF switches shall be positioned so that the key is vertical when the switch is OFF. [Source: MIL-STD-1472F, 1999]

- **6.1.5.2.7 Direction of rotation.** The key should turn clockwise from the vertical OFF position to the ON position. [Source: MIL-STD-1472F, 1999]

- **6.1.5.2.8 Key removal.** Users should normally be able to remove the key from the switch only when the switch is in the OFF position. [Source: MIL-STD-1472F, 1999]

6.1.5.3 Discrete thumbwheel controls

- **6.1.5.3.1 When to use.** Thumbwheel controls should be used only when the function requires a compact digital input device, for example, to enter a series of numbers, and a readout is needed for verification. [Source: MIL-STD-1472F, 1999]

- **6.1.5.3.2 Shape.** Each position around the circumference of a discrete thumbwheel shall have a concave surface or be separated by a high-friction area that is raised from the periphery of the thumbwheel. [Source: MIL-STD-1472F, 1999]

- **6.1.5.3.3 Viewing of thumbwheel digits.** The thumbwheel shall not preclude viewing the digits within a 30° viewing angle to the left and right of a perpendicular to the thumbwheel digits. [Source: MIL-STD-1472F, 1999]

- **6.1.5.3.4 Coding.** Thumbwheel controls should be coded by location, labeling, and color (e.g., reversing the colors of the least significant digit wheel as on typical odometers). [Source: MIL-STD-1472F, 1999]

- **6.1.5.3.5 Coding of thumbwheel switches.** Where used as input devices, thumbwheel switch Off or Normal positions should be color coded to permit a visual check that the digits have been reset to their Off or Normal positions. [Source: MIL-STD-1472F, 1999]

- **6.1.5.3.6 Direction of movement.** Moving the thumbwheel edge forward, upward, or to the right shall increase the setting. [Source: MIL-STD-1472F, 1999]

- **6.1.5.3.7 Internal illuminance and appearance of characters.** When ambient illumination will provide visual indicator illuminance less than 3.5 cd/m^2 (1 fL), the thumbwheel shall be illuminated internally with the digits appearing as illuminated characters on a black background, with approximate dimensions as follows:

  a. height: at least 4.8 mm (0.19 in),

  b. height-to-width ratio: 3:2, and

  c. height-to-stroke width ratio: 10:1. [Source: MIL-STD-1472F, 1999]

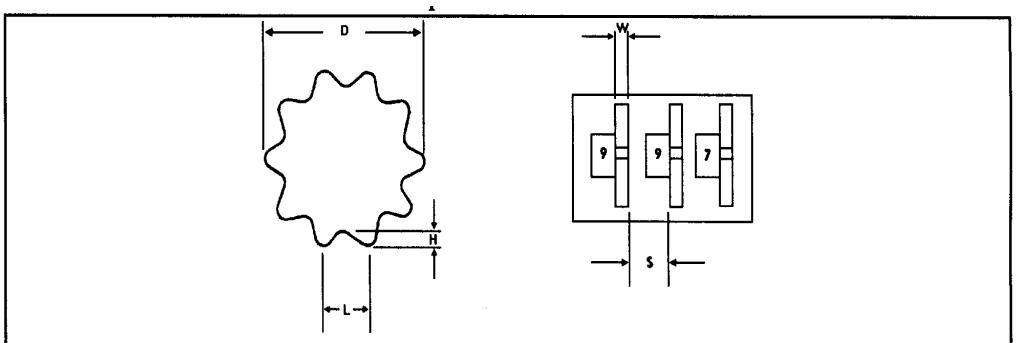
- **6.1.5.3.8 External illuminance and appearance of characters.** When external illumination is used, digits should be bold, black numerals engraved on a light or white background with the dimensions approximately as those in Paragraph 6.1.5.3.7, with a height-to-stroke width ratio approximately 5:1. [Source: MIL-STD-1472F, 1999]

  Discussion. When ambient illumination will provide visual indicator illuminance equal to or greater than 3.5 cd/m2 (1 fL), internal illumination is not required.

- **6.1.5.3.9 Visibility.** Thumbwheel design shall permit viewing of inline digital read-out from all operator positions. [Source: MIL-STD-1472F, 1999]

- **6.1.5.3.10 Dimensions.** Thumbwheel dimensions shall not exceed the maximum and minimum dimensions given in Exhibit 6.1.5.3.10. [Source: MIL-STD-1472F, 1999]

Exhibit 6.1.5.3.10 Discrete thumbwheel dimensions



	D Trough Diameter	L distance	W Width	H Depth	S Separation	Resistance
Minimum	30 mm (1.1 in)	11 mm (0.4 in)	3 mm (0.1 in)	3 mm (0.1 in)	10 mm (0.4 in)	1.7 N (6 oz)
Maximum	75 mm (3 in)	19 mm (0.75 in)	--	13 mm (0.5 in)	--	5.6 N (20 oz)

- **6.1.5.3.11 Provide detents.** Detents shall be provided for discrete position thumbwheels. [Source: MIL-STD-1472F, 1999]

- **6.1.5.3.12 Increase resistance between detents** Resistance shall increase between detents (within the limits given in Exhibit 6.1.5.3.10) so that the thumbwheel will not rest between detents, but rather will snap into position at a detent. [Source: MIL-STD-1472F, 1999]

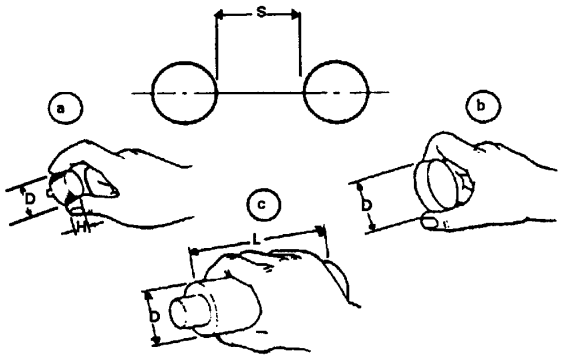
- **6.1.5.3.13 Separation.** Adjacent edges of thumbwheel controls shall be separated by at least 10 mm (0.4 in to preclude accidental activation of adjacent controls during use. [Source: MIL-STD-1472F, 1999]

6.1.5.4 Knobs

- **6.1.5.4.1 Knob specifications.** The dimensions of knobs shall not exceed the maximum and minimum values specified in Exhibit 6.1.5.4.1 with torque (turning resistance) and separation between adjacent edges of knobs conforming to the values given in the exhibit. [Source: MIL-STD-1472F, 1999]

  Discussion. Within the limits stated, and provided that resistance is low and that the knob can be easily grasped, knob size is relatively unimportant. If panel space is limited, knobs may approximate the minimum values, with their resistance as low as possible, but not so low that they might be turned by vibration or by a mere touch. [Source: MIL-STD-1472F, 1999]

Exhibit 6.1.5.4.1 Knob Specifications



	a Fingertip grasp		b Thumb and finger encircled	c Palm grasp	
	H Height	D Diameter	D Diameter	D Diameter	L Length
Minimum	13 mm (0.5 in)	10 mm (0.4 in)	25 mm (1.0 in)	38 mm (1.5 in)	75 mm (3.0 in)
Maximum	25 mm (1.0 in)	100 mm (4.0 in)	75 mm (3.0 in)	75 mm (3.0 in)	

	Torque		Separation	
	†	‡	S One hand individually	S Two hands simultaneously
Minimum	--	--	25 mm (1 in)	50 mm (2 in)
Optimum	--	--	50 mm (2 in)	125 mm (5 in)
Maximum	32 mN*m (4.5 in*oz)	42 mN*m (6.0 in*oz)	--	--

† To and including 25 mm (1 in) diameter knobs
‡ Greater than 25 mm (1 in) diameter knobs

- **6.1.5.4.2 When to use.** A knob should be used if low force or precise adjustment of a continuous variable is required. [Source: MIL-STD-1472F, 1999]

- **6.1.5.4.3 Moving knob vs fixed scale knob.** A moving knob with a fixed scale should be used rather than a moving scale with a fixed index for most tasks. [Source: MIL-STD-1472F, 1999]

- **6.1.5.4.4 Single-revolution knob.** When the position of a single-revolution knob must be distinguishable, the knob should have a pointer or marker. [Source: MIL-STD-1472F, 1999]

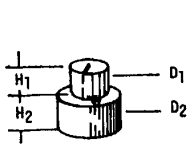
- **6.1.5.4.5 Knob style.** Rotating knob controls for different types of control actions should be distinguishable both visually and tactually and not be easily confused with one another. [Source: NUREG-0700, 1981]

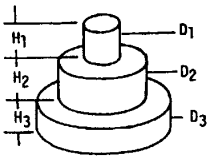
- **6.1.5.4.6 Knob position indication.** When knowledge of the position of a knob or its setting is important, the knob should be shape coded or include a pointer or other means to make its position apparent. [Source: NUREG-0700, 1981]

6.1.5.5 Ganged control knobs

- **6.1.5.5.1 Ganged control knob specifications.** The dimensions for two and three knob assemblies shall not exceed the maximum or minimum values given in Exhibit 6.1.5.5.1 with torque (turning resistance) not exceeding the values given in the exhibit and separation at least at the minimum given in the exhibit for the appropriate type of operation. [Source: MIL-STD-1472F, 1999]

Exhibit 6.1.5.5.1 Ganged control knob specifications





	Two knob assembly				Three knob assembly					
	H_1	H_2	D_1	D_2	H_1	H_2	H_3	D_1	D_2	D_3
Minimum	16 mm (.6 in)	13 mm (.5 in)	13 mm (.5 in)	22 mm (.9 in)	19 mm (.75 in)	19 mm (.75 in)	6 mm (.25 in)	13 mm (.5 in)	44 mm (1.75 in)	75 mm (3 in)
Maximum	-	-	-	100 mm (4 in)	-	-	-	-	-	100 mm (4 in)

	Torque		Separation			
			One hand individually		Two hand simultaneously	
	†	‡	Bare	Gloved	Bare	Gloved
Minimum	--	--	25 mm (1.0 in)	63 mm (2.5 in)	50 mm (2.0 in)	90 mm (3.5 in)
Optimum	--	--	50 mm (2.0 in)	90 mm (3.5 in)	75 mm (3.0 in)	100 mm (4.0 in)
Maximum	32 mN*m (4.5 in*oz)	42 mN*m (6.0 in*oz)	--	--	--	--

† To and including 25 mm (1.0 in) diameter knobs
‡ Greater than 25 mm (1.0 in) diameter knobs

- **6.1.5.5.2 When to use.** Ganged knob assemblies should be used only if panel space is limited and when used, the number ganged should be minimized. [Source: MIL-STD-1472F, 1999]

- **6.1.5.5.3 Three-knob assemblies.** Three-knob assemblies should be avoided. [Source: MIL-STD-1472F, 1999]

- **6.1.5.5.4 When to avoid.** Ganged knobs should not be used under the following conditions:

  a. Extremely accurate or rapid operations are required.

  b. Frequent changes are necessary.

  c. The user is likely to be wearing gloves.

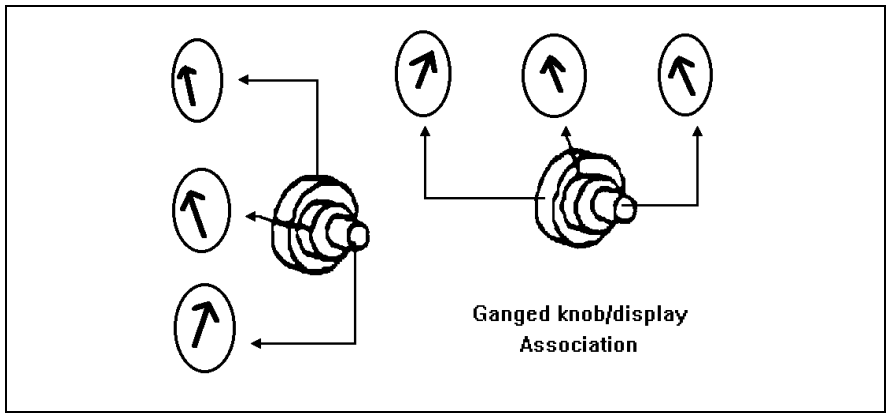
  d. The equipment is likely to be exposed to weather or field conditions. [Source: MIL-STD-1472F, 1999]

- **6.1.5.5.5 Serrations.** Knobs should be serrated with knobs for precise adjustments having fine serrations and knobs for gross adjustments having coarse serrations. [Source: MIL-STD-1472F, 1999]

- **6.1.5.5.6 Marking.** An indexing mark or pointer shall be provided for each knob and differ sufficiently from one knob in an assembly to another so that it is apparent which indexing mark is associated with which knob. [Source: MIL-STD-1472F, 1999]

- **6.1.5.5.7 Knob and visual indicator relationship.** When the knobs of a ganged assembly are associated with an array of visual indicators, the knob closest to the panel shall be associated with the left-most visual indicator in a horizontal array or to the uppermost visual indicator in a vertical array, as illustrated in Exhibit 6.1.5.5.7. [Source: MIL-STD-1472F, 1999]

  Exhibit 6.1.5.5.7 Relationship between ganged knobs and their associated visual indicators
  [Source: DOE-HFAC1, 1992]



- **6.1.5.5.8 Inadvertent movement, critical.** When it is critical that one knob not be moved inadvertently while another knob is being moved, a secondary knob control movement shall be required. [Source: MIL-STD-1472F, 1999]

  Example. It might be necessary to press the top knob in or down to engage its control shaft. [Source: MIL-STD-1472F, 1999]

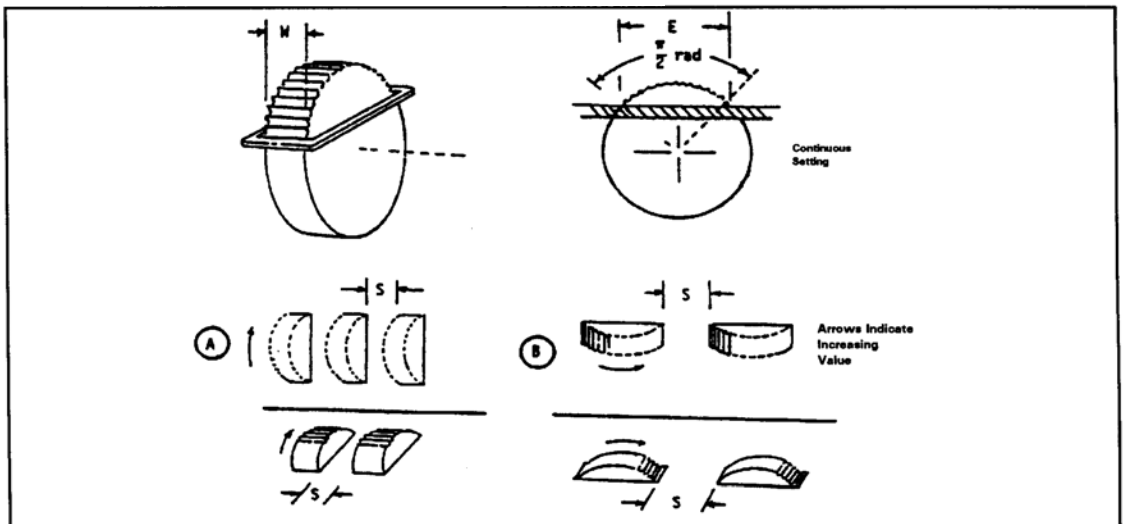
- **6.1.5.5.9 Inadvertent movement, non-critical.** When inadvertent movement of one knob while another is being adjusted is undesirable but not critical, the "optimum" separation dimensions in Exhibit 6.1.5.5.1 should be used. [Source: MIL-STD-1472F, 1999]

  Discussion. Using different colors for the individual knobs can help in their identification. [Source: MIL-STD-1472F, 1999]

6.1.5.6 Continuous adjustment thumbwheels

- **6.1.5.6.1 Continuous thumbwheel specifications.** The dimensions, separation, and resistance of thumbwheels shall not exceed the maximum and minimum values given in Exhibit 6.1.5.6.1. [Source: MIL-STD-1472F, 1999]

Exhibit 6.1.5.6.1 Continuous thumbwheel specifications



	E Rim exposure	W Width	S A	S B	Resistance
Minimum	25 mm † (1.0 in)	3 mm (0.1 in)	25 mm (1.0 in) Add 13 mm (0.5 in) for gloves	50 mm (2.0 in) Add 25 mm (1.0 in) for gloves	To minimize effects of inadvertent input if operator subject to motion
Maximum	100 mm (4.0 in)	23 mm (0.9 in)	N/A	N/A	3.3 N (12 oz)

† Preferred. Some miniature applications may require less.

- **6.1.5.6.2 When to use.** When an application will benefit from the compactness of a thumbwheel, a continuously adjustable thumbwheel should be used rather than a rotary knob. [Source: MIL-STD-1472F, 1999]

- **6.1.5.6.3 Orientation and movement.** Thumbwheels shall be oriented and move in the directions specified in Exhibit 6.1.5.6.1. [Source: MIL-STD-1472F, 1999]

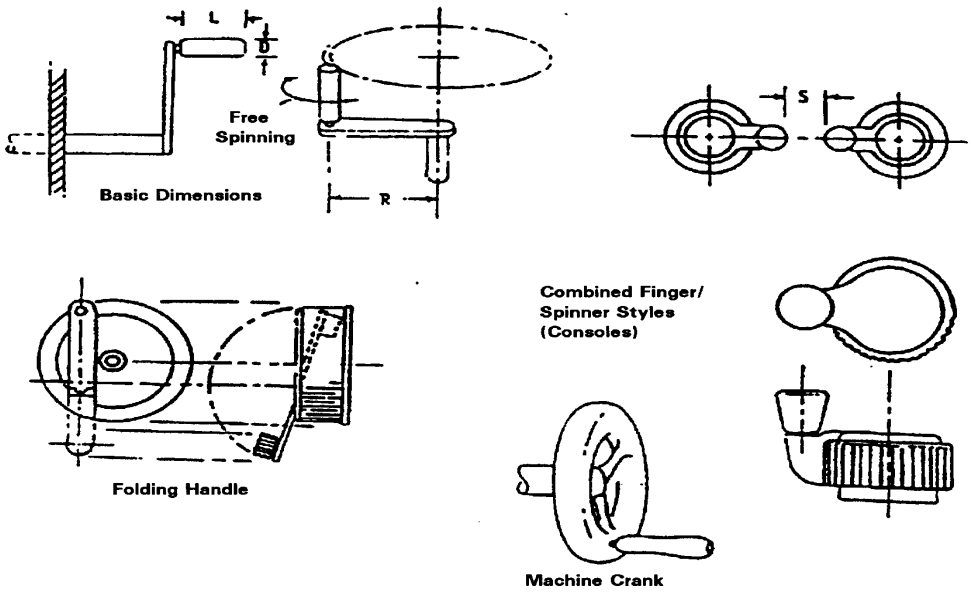
- **6.1.5.6.4 Turning aids.** The rim of a thumbwheel shall be serrated or provided with a high friction surface to make it easy to turn. [Source: MIL-STD-1472F, 1999]

- **6.1.5.6.5 OFF position.** A continuous adjustment thumbwheel that has an OFF position shall have a detent at that position. [Source: MIL-STD-1472F, 1999]

6.1.5.7 Cranks

- **6.1.5.7.1 Crank specifications.** The dimensions, resistance, and separation of adjacent circular swept areas of cranks shall not exceed the maximum and minimum values given in Exhibit 6.1.5.7.1. [Source: MIL-STD-1472F, 1999]

Exhibit 6.1.5.7.1 Crank specifications



		Handle		R, Turning radius	
Load	Specification	L, length	D, diameter	Rate below 100 RPM	Rate above 100 RPM
Light loads: Less than 22N (5.0 lb) (Wrist and finger movement)	Minimum	25 mm(1.0 in)	10 mm(0.4 in)	38 mm(1.5 in)	13 mm(0.5 in)
	Preferred	38 mm(1.5 in)	13 mm(0.5 in)	75 mm(3.0 in)	65 mm(2.5 in)
	Maximum	75 mm(3.0 in)	16 mm(0.6 in)	125 mm(5.0 in	115 mm(4.5 in)
Heavy loads: 22 N (5.0 lb) or more. arm movement)	Minimum	75 mm(3.0 in)	25 mm(1.0 in)	190 mm(7.5 in)	125 mm(5.0 in)
	Preferred	95 mm(3.75 in)	25 mm(1.0 in)	-- --	-- --
	Maximum	-- --	38 mm(1.5 in)	510 mm(20.0 in)	230 mm(9.0 in)

▫ **6.1.5.7.2 When to use.** Cranks should be used for any task that requires many rotations of a control, particularly if high rates or large forces are involved. [Source: MIL-STD-1472F, 1999]

Discussion. For tasks that involve large slewing movements as well as small, fine adjustments, a crank handle may be mounted on a knob or hand wheel. The crank would then be used for slewing and the knob or hand wheel for the fine adjustment.

▫ **6.1.5.7.3 Numerical selection.** When a crank is used for tuning or another process involving numerical selection, each rotation of the crank should correspond to a multiple of 1, 10, 100, or other appropriate value. [Source: MIL-STD-1472F, 1999]

▫ **6.1.5.7.4 Extreme precision in numerical selection.** When extreme precision is required in an X-Y control, for example, in setting crosshairs or reticles in reading a map, a simultaneously operated pair of hand cranks should be used in preference to other two-axis controllers. [Source: MIL-STD-1472F, 1999]

Discussion. Be certain that the gear ratios and dynamic characteristics of such cranks permit precise placement of the followers without over- or undershooting and successive corrective movements. [Source: MIL-STD-1472F, 1999]

▪ **6.1.5.7.5 Grip handle.** The handle of a hand crank shall turn freely around its shaft. [Source: MIL-STD-1472F, 1999]

▫ **6.1.5.7.6 Folding handles.** When a crank handle might be a hazard to persons passing by, or if it is critical that the handle not be moved inadvertently, a folding handle should be used that is stable in both the extended and folded positions. [Source: MIL-STD-1472F, 1999]

▪ **6.1.5.7.7 Crank balance.** In applications in which resistance is low, the crank shall be balanced so that the weight of the handle does not move the crank from its last setting. [Source: MIL-STD-1472F, 1999]

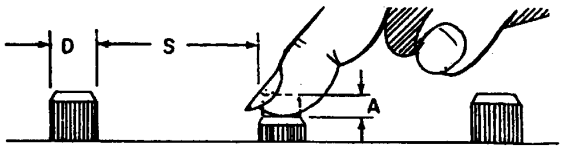
6.1.5.8 Push buttons

- **6.1.5.8.1 Push button specifications.** The dimensions, resistance, displacement, and separation of push buttons shall not exceed the maximum and minimum values given in Exhibit 6.1.5.8.1. [Source: MIL-STD-1472F, 1999]

  Exception. Push buttons used in keyboards are exempt from this requirement. [Source: MIL-STD-1472F, 1999]

  Note. Mechanical interlocks or barriers may be used instead of the separation specified in Exhibit 6.1.5.8.1. [Source: MIL-STD-1472F, 1999]

Exhibit 6.1.5.8.1 Push button specifications



Dimensions

	Diameter D		Resistance		
	Fingertip	Thumb or palm	Single finger	Different fingers	Thumb or palm
Minimum	9.5 mm (0.375 in)	19 mm (0.75 in)	2.8 N (10 oz)	1.4 N (5 oz)	2.8 N (10 oz)
Maximum	25 mm (1 in)		11 N (40 oz)	5.6 N (20 oz)	23 N (80 0z)

Displacement A

	Fingertip	Thumb or palm
Minimum	2 mm (0.08 in)	3 mm (0.125 in)
Maximum	6 mm (0.25 in)	38 mm (1.5 in)

Separation S

	Single finger		Different	
	Single finger	sequential	fingers	Thumb or palm
Minimum	13 mm (0.5 in)	6 mm (0.25 in)	6 mm (0.25 in)	25 mm (1 in)
Preferred	50 mm (2 in)	13 mm (0.5 in)	13 mm (0.5 in)	150 mm (6 in)

Note: These data are for barehand operation. For gloved hand operation, the minimum values should be suitably adjusted

- **6.1.5.8.2 When to use.** Push buttons should be used if a control is needed for momentary contact or to activate a locking circuit, particularly if the control will be used frequently. [Source: MIL-STD-1472F, 1999]

- **6.1.5.8.3 When not to use.** Push buttons shall not be used if the status of a function must be indicated by the position of its control. [Source: MIL-STD-1472F, 1999]

- **6.1.5.8.4 Shape.** The surface of a push button should be concave to accommodate a fingertip. If it is not concave, it should have a nonslip surface. [Source: MIL-STD-1472F, 1999]

- **6.1.5.8.5 Positive feedback.** A push button shall provide positive feedback of operation, for example, a "snap" action, an audible click, or an integral light. [Source: MIL-STD-1472F, 1999]

- **6.1.5.8.6 Prevention of inadvertent operation.** A channel or cover guard shall be provided when accidental actuation of the control must be prevented. [Source: MIL-STD-1472F, 1999]

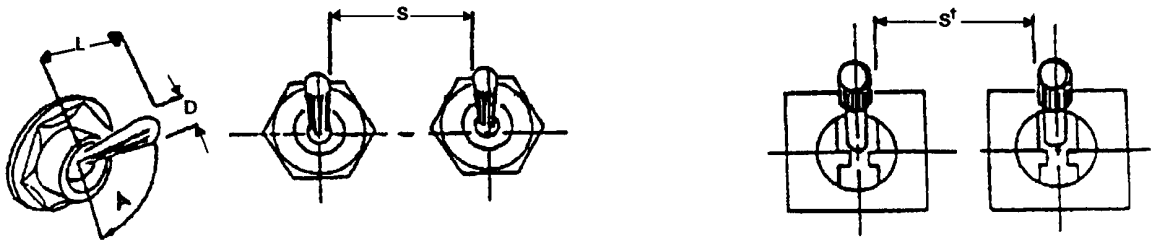
- **6.1.5.8.7 Non-interference by cover guard.** When a cover guard is in the open position, it shall not interfere with operation of the protected device or adjacent controls. [Source: MIL-STD-1472F, 1999]

6.1.5.9 Toggle switches

- **6.1.5.9.1 Toggle switch specifications.** The dimensions, resistance, displacement, and separation of toggle switches shall not exceed the maximum and minimum values given in Exhibit 6.1.5.9.1. [Source: MIL-STD-1472F, 1999]

  Definition. A **toggle switch** is a switch with discrete positions operated by a lever. Controls having the same size and shape, but that allow continuous adjustments are **levers**. [Source: MIL-STD-1472F, 1999]

Exhibit 6.1.5.9.1 Toggle switch specifications



	Dimensions			Resistance	
	L Arm length *	L Arm length **	D Control tip	Small switch	Large switch
Minimum	13 mm (0.5 in)	38 mm (1.5 in)	3 mm (0.13 in)	2.8 N (10 oz)	2.8 N (10 oz)
Maximum	50 mm (2 in)	50 mm (2 in)	25 mm (1 in)	4.5 N (16 oz)	11 N (40 oz)

Displacement between positions

	A	
	2 position	3 position
Minimum	30°	17°
Maximum	80°	40°
Preferred	-	25°

	Separation			
	S Single finger operation †	S Single finger sequential operation	Simultaneous operation by different fingers	
Minimum	19 mm (0.75 in)	25 mm (1 in)	13 mm (0.5 in)	16 mm (0.63 in)
Optimum	50 mm (2 in)	50 mm (2 in)	25 mm (1 in)	19 mm (0.75 in)

* Use by bare hand
** Use with heavy handwear
† Using a lever lock toggle switch

- **6.1.5.9.2 Toggle switch resistance.** The resistance of a toggle switch shall increase as the switch is moved toward its midpoint, then decrease as the switch "snaps" into its alternate position. (See Exhibit 6.1.5.9.1). [Source: MIL-STD-1472F, 1999]

- **6.1.5.9.3 Toggle switch position.** The switch shall not be capable of remaining between positions without being held. (See Exhibit 6.1.5.9.1). [Source: MIL-STD-1472F, 1999]

- **6.1.5.9.4 When to use.** Toggle switches should be used for functions that require two discrete positions or where space limitations are severe. [Source: MIL-STD-1472F, 1999]

- **6.1.5.9.5 Three-position toggle switches.** A toggle switch having three positions shall be used only if (1) the use of some other type of control such as a rotary switch or a legend switch is not feasible, or (2) the toggle switch is a spring-loaded switch with the center position being the OFF position. [Source: MIL-STD-1472F, 1999]

- **6.1.5.9.6 Spring-loaded toggle switches.** A toggle switch that latches in one position and is spring-loaded to return to center from the other shall not be used if release from the spring-loaded position would allow the switch lever to travel past the center position. [Source: MIL-STD-1472F, 1999]

- **6.1.5.9.7 Preventing accidental actuation.** When it is imperative that a toggle switch not be operated inadvertently, for example, if actuation might result in a critical or hazardous condition, the switch shall be protected by means of a barrier or a cover, however, not by safety or lock wire. [Source: MIL-STD-1472F, 1999]

- **6.1.5.9.8 Cover lifting resistance.** The resistance to lifting a cover shall not exceed 13 N (3 lb). [Source: MIL-STD-1472F, 1999]

- **6.1.5.9.9 Non-interference of cover.** When a cover is used, it shall not interfere with the operation of the switch or of adjacent controls. [Source: MIL-STD-1472F, 1999]

- **6.1.5.9.10 Positive feedback.** A toggle switch shall provide positive feedback, for example, a "snap" action, an audible click, or an integral or associated light. [Source: MIL-STD-1472F, 1999]

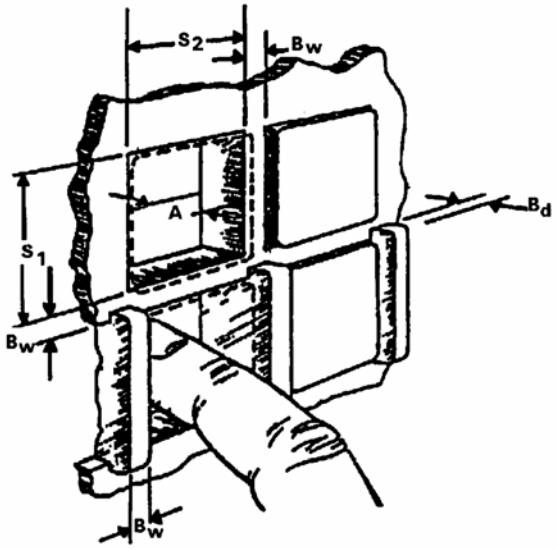
- **6.1.5.9.11 Vertical orientation.** Toggle switches should be oriented vertically, and, if applicable, make OFF be in the down position. [Source: MIL-STD-1472F, 1999]

- **6.1.5.9.12 Horizontal orientation.** A horizontal orientation should be used only to make the switch compatible with its controlled function or equipment location. [Source: MIL-STD-1472F, 1999]

6.1.5.10 Legend switches

- **6.1.5.10.1 Legend switch specifications.** The dimensions, resistance, and displacement of legend switches and the separation of adjacent legend switches shall not exceed the maximum and minimum values given in Exhibit 6.1.5.10.1. [Source: MIL-STD-1472F, 1999]

Exhibit 6.1.5.10.1 Legend switch specifications



	S_1, S_2 Size	A Displacement	Barriers B_w	Barriers B_d	Resistance
Minimum	19 mm* (0.75 in)	3 mm** (0.13 in)	3 mm (0.13 in)	5 mm (0.38 in)	2.8 N*** (10 oz)
Maximum	38 mm (1.5 in)	6 mm (0.25 in)	6 mm (0.25 in)	6 mm (0.25 in)	16.7 N (60 oz)

* 15 mm (0.63 in) where the switch is not depressed below the panel.
** 5 mm (0.38 in) for positive position switches.
*** 5.6 N (20 oz) for use in moving vehicles.

- **6.1.5.10.2 Avoiding inadvertent activation.** Critical switches and switches likely to be activated inadvertently shall have barriers unless specified otherwise. [Source: MIL-STD-1472F, 1999]

- **6.1.5.10.3 Avoiding inadvertent activation.** The height of barriers (measured from the surface of the panel) shall not exceed the maximum and minimum values given in Exhibit 6.1.5.10.1. [Source: MIL-STD-1472F, 1999]

- **6.1.5.10.4 Positive feedback.** A legend switch shall provide positive feedback of operation, for example, a "snap" action, an audible click, or an integral or associated light. [Source: MIL-STD-1472F, 1999]

- **6.1.5.10.5 Legibility of legend.** The legend on a legend switch shall be legible with and without internal illumination. [Source: MIL-STD-1472F, 1999]

- **6.1.5.10.6 Lamp replacement.** The lamp within a legend switch shall be replaceable from the front of the panel by hand. [Source: MIL-STD-1472F, 1999]

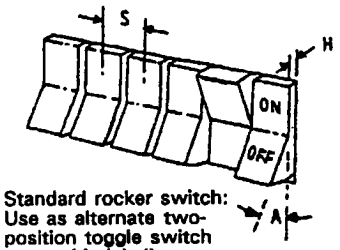
- **6.1.5.10.7 Cover replacement.** The covers of legend switches should be marked or coded to ensure that each cover can be replaced on its associated switch if it has been removed. [Source: MIL-STD-1472F, 1999]

- **6.1.5.10.8 Legends.** The legend on a legend switch shall not exceed three lines of characters. [Source: MIL-STD-1472F, 1999]

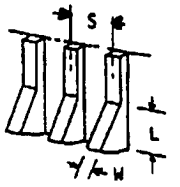
6.1.5.11 Rocker switches

- **6.1.5.11.1 Rocker switch specifications.** The dimensions, resistance, displacement, and separation of rocker switches shall not exceed the maximum and minimum values given in Exhibit 6.1.5.11.1. [Source: MIL-STD-1472F, 1999]

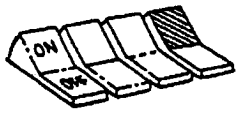
Exhibit 6.1.5.11.1 Rocker switch specifications



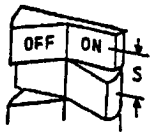
Standard rocker switch: Use as alternate two-position toggle switch to provide labeling surface, ease of color coding, and switch illumination.



Narrow width, especially desirable for tactile definition with gloves.



Alternate (contrast) color for on versus off to provide conspicuous cue of switch position. Illuminated "on" desirable as second feedback cue.



	Dimensions		Resistance
	W, width	L, length	
Minimum	6 mm (0.25 in)	13 mm (0.5 in)	2.8 N (10 oz)
Maximum			11 N (40 oz)

	Displacement		Separation (center-to-center)	
	H, height depressed	A, angle	S (Bare hand)	S (Gloved hand)
Minimum	3 mm (0.1 in)	30°	19 mm (0.75 in)	32 mm (1.25 in)

- **6.1.5.11.2 Rocker switch resistance.** The resistance of a rocker switch shall increase as the upper portion is pressed down or in, then decrease so that the switch "snaps" into position. [Source: MIL-STD-1472F, 1999]

  Discussion. It may be desirable to color code the two portions of a rocker switch as an aid in identifying the switch's position, for example, the portion indicating ON might be one color, and the portion indicating OFF might be another. [Source: MIL-STD-1472F, 1999]

- **6.1.5.11.3 Rocker switch position.** A rocker switch shall not be capable of stopping between positions. [Source: MIL-STD-1472F, 1999]

- **6.1.5.11.4 When to use.** Rocker switches should be used rather than toggle switches if (1) a toggle switch handle might interfere with or be interfered with surrounding activity, or (2) panel space is too limited for the labeling of toggle switch positions. [Source: MIL-STD-1472F, 1999]

- **6.1.5.11.5 Three-position rocker switches.** Rocker switches with three positions shall be used only if (1) the switch is spring-loaded, with the center position being OFF, or (2) the use of another type of control such as a rotary switch or a legend switch is not feasible. [Source: MIL-STD-1472F, 1999]

- **6.1.5.11.6 Preventing accidental actuation.** If it is imperative that a rocker switch not be operated inadvertently, for example, if actuation might result in a critical or hazardous condition, the switch shall be protected, for example, with a channel guard, barrier, cover, or an equivalent protective measure. [Source: MIL-STD-1472F, 1999]

- **6.1.5.11.7 Positive feedback.** A rocker switch shall provide positive feedback of operation, for example, a "snap" action, an audible click, or an integral or associated light. [Source: MIL-STD-1472F, 1999]

- **6.1.5.11.8 Orientation.** When practicable, rocker switches shall be oriented vertically. Actuation of the upper portion, that is, depressing it, shall turn the equipment or component ON, cause a quantity to increase, or cause movement of a unit equipment or a component clockwise, forward, up, or to the right. Rocker switches shall be oriented horizontally only to make the switch compatible with the controlled function or equipment location. [Source: MIL-STD-1472F, 1999]

- **6.1.5.11.9 Illumination.** When a rocker switch will be used where the ambient illumination will provide visual indicator illuminance of less than 3.5 cd/m^2 (1 fL), the switch should be illuminated internally. [Source: MIL-STD-1472F, 1999]

- **6.1.5.11.10 Labels.** When a rocker switch is illuminated, any alphanumeric characters shall appear as illuminated characters on an opaque background. [Source: MIL-STD-1472F, 1999]

- **6.1.5.11.11 Character size on illuminated rocker switches.** When a rocker switch is illuminated, any alphanumeric characters shall:

  a. be at least 4.8 mm (0.19 in) in height,

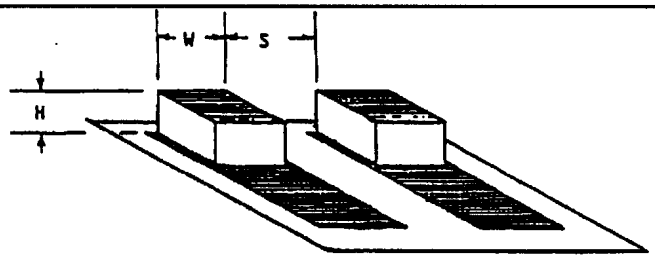
  b. have a height-to-width ratio of 3:2, and

  c. have a height-to-stroke-width ratio of 10:1. [Source: MIL-STD-1472F, 1999]

6.1.5.12 Slide switches

- **6.1.5.12.1 Slide switch specifications.** The dimensions, resistance, and separation of slide switches shall not exceed the maximum and minimum values given in Exhibit 6.1.5.12.1. [Source: MIL-STD-1472F, 1999]

Exhibit 6.1.5.12.1 Slide switch specifications



	Dimensions			Resistance	
	H Actuator height †	‡	W Actuator width	Small switch	Large switch
Minimum	6 mm (0.25 in)	13 mm (0.5 in)	6 mm (0.1 in)	2.8 N (10 oz)	2.8 N (10 oz)
Maximum	-	-	25 mm (1.0 in)	4.5 N (16 oz)	11 N (40 oz)

	S, separation		
	Single finger operation	Single finger sequential operation	Simultaneous operation by different fingers
Minimum	19 mm (0.75 in)	13 mm (0.5 in)	16 mm (0.6 in)
Optimum	50 mm (2.0 in)	25 mm (1.0 in)	19 mm (0.75 in)

† Use with bare
‡ Use with heavy handwear

- **6.1.5.12.2 Detents.** Each position of a slide switch shall have a detent. [Source: MIL-STD-1472F, 1999]

- **6.1.5.12.3 Slide switch resistance.** Resistance between positions shall increase and then decrease so that the switch "snaps" into position. [Source: MIL-STD-1472F, 1999]

- **6.1.5.12.4 Slide switch location.** A slide switch shall not be capable of stopping between positions. [Source: MIL-STD-1472F, 1999]

- **6.1.5.12.5 Preventing accidental actuation.** When it is imperative that a slide switch not be operated inadvertently, for example, when operation might result in a critical or hazardous condition, the switch shall be protected. [Source: MIL-STD-1472F, 1999]

  Discussion. Protection might be by means of a channel guard, barrier, cover, or an equivalent protective measure. [Source: MIL-STD-1472F, 1999]

- **6.1.5.12.6 Vertical orientation.** Slide switches shall be oriented vertically, with movement of the slide up or away from the user turning the equipment or component ON, causing a quantity to increase, or causing the equipment or component to move clockwise, forward, up, or to the right. [Source: MIL-STD-1472F, 1999]

- **6.1.5.12.7 Horizontal orientation.** Horizontal orientation shall be used only to make the switch compatible with its controlled function or equipment location. [Source: MIL-STD-1472F, 1999]

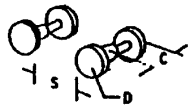
- **6.1.5.12.8 Positive feedback.** A slide switch that has more than two positions shall provide an indication of its setting, for example, by means of a pointer located on the side of the slide handle. [Source: MIL-STD-1472F, 1999]

6.1.5.13 Discrete push-pull controls

- **6.1.5.13.1 Push-pull control specifications.** The dimensions, displacement, and separation of push-pull controls shall not exceed the maximum and minimum values given in Exhibit 6.1.5.13.1. [Source: MIL-STD-1472F, 1999]

  Discussion. Push-pull controls may be used to select one of two discrete functions or, if panel space is limited, to combine two related, but distinct functions, such as a combination ON-OFF switch and volume control into a single control. A three-position push-pull control may be acceptable in isolated instances in which the criticality of inadvertent selection of the wrong position has no serious consequences; for example, the OFF-parking lights-headlights switch on some automobiles. [Source: MIL-STD-1472F, 1999]

Exhibit 6.1.5.13.1 Push-pull control specifications

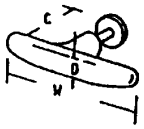


Push-pull control, low resistance, for two-position, mechanical and electrical systems. Alternate three position plus rotary function acceptable for application such as vehicle headlight plus parking lights, panel and dome lights. Provide serrated rim.

Minimium diamter (D)	Minimum clearance (C)	Displacement	Minimum space (S) between controls:
19 mm (0.75 in)	25 mm (1.0 in) add13 mm (0.5 in) for gloved hand	12-38 mm (0.5-1.5 in) Minimum between pull positons: 13 mm (0.5 in)	38 mm (1.5 in) add13 mm (0.5 in) for gloved hand

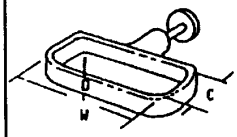
Alternate handle; miniature electrical panel switch only. Avoid glove use application.

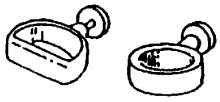
Minimum diameter (D)	Minimum clearance (C)	Minimum length	Minimum displacement	Minimum space between (S)
6.5 mm (0.25 in)	N/A	19 mm (0.75 in)	13 mm (0.5 in)	25 mm (1 in)



High force push-pull, for two-position mechanical system only.

Minimum width (W)	Depth (D)	Minimum clearance (C)	Minimum displacement
100 mm (4 in)	16-38 mm (0.6-1.5 in)	38 mm (1.5 in) add 6 mm (0.24 in) for gloved hand	25 mm (1 in) Preferred: 50 mm (2 in)





Same as above. The following values are preferred where possible garment or cable-snag possibility exists.

Minimum width (W)	Depth (D)	Minimum clearance (C)	Minimum displacement	Minimum space between (S)
100 mm (4 in)	16-38 mm (0.6 in - 1.5 in)	38 mm (1.5 in)	25 mm (1 in) Preferred: 50 mm (2 in)	13 mm (0.5 in)

Note. 1 and 2 finger pulls are also acceptable for less than 18 N (4.0 lb) application

- **6.1.5.13.2 When to use.** Push-pull controls should be used sparingly and primarily in applications in which they have been used traditionally, for example, vehicle headlight switches. [Source: MIL-STD-1472F, 1999]

- **6.1.5.13.3 Rotation.** Push-pull controls shall normally be keyed to a nonrotating shaft. Exceptions are (1) combination push-pull and rotate controls, and (2) special applications, for example, one in which a handle is rotated to disengage something. Combination push-pull and rotate knobs shall have a serrated rim to suggest both visually and tactually that the knob can be rotated and to help prevent fingers from slipping when they turn the knob. [Source: MIL-STD-1472F, 1999]

- **6.1.5.13.4 Detents.** Push-pull controls shall have detents to provide tactile indication of positions. [Source: MIL-STD-1472F, 1999]

- **6.1.5.13.5 Snagging and inadvertent operation.** Push-pull controls shall be designed and located to prevent

  a. the snagging of clothing, wires, and cables,

  b. their being bumped by passers by, and

  c. their being bumped by someone reaching for or operating another nearby control. [Source: MIL-STD-1472F, 1999]

- **6.1.5.13.6 Direction of movement.** The direction of movement of a push-pull control shall conform to the following:

  a. Pulling the control toward the user shall turn ON or actuate the associated equipment or function; pushing the control away from the user shall turn OFF or deactuate the equipment or function.

  b. Turning a combination push-pull and rotary control clockwise shall actuate or increase the function. [Source: MIL-STD-1472F, 1999]

- **6.1.5.13.7 Resistance for a panel control.** The force required to push or pull a panel control with the fingers should not exceed 18 N (4 lb). [Source: MIL-STD-1472F, 1999]

- **6.1.5.13.8 Resistance for a T-bar.** The force required to push or pull a T-bar with four fingers should not exceed 45 N (10 lb). [Source: MIL-STD-1472F, 1999]

6.1.5.14 Printed circuit switches

Printed circuit (PC) switches may be used if manual programming functions are needed in systems that employ printed circuit boards. [Source: MIL-STD-1472F, 1999]

- **6.1.5.14.1 Dimensions.** PC switches shall be large enough to permit error-free manipulation by a person using a pencil or pen. PC switch actuators shall not require the use of a special tool for their operation. [Source: MIL-STD-1472F, 1999]

- **6.1.5.14.2 Resistance.** The resistance of a PC switch shall be high enough to avoid inadvertent actuation under the expected conditions of use, increase to a maximum halfway between positions, then decrease again so that the switch actuator "snaps" into position, and not be capable of stopping between positions. [Source: MIL-STD-1472F, 1999]

- **6.1.5.14.3 Displacement.** Sliding PC switch actuators shall have enough displacement to permit easy identification of the switch position with displacement at least twice the width or thickness of the actuator. [Source: MIL-STD-1472F, 1999]

- **6.1.5.14.4 Rocker switches.** When rocker switches are used, the actuated portion of the switch shall be flush with the panel surface. [Source: MIL-STD-1472F, 1999]

- **6.1.5.14.5 Separation.** When two or more PC switches are grouped together, their actuators shall be far enough apart to permit error-free operation of the individual switches. [Source: MIL-STD-1472F, 1999]

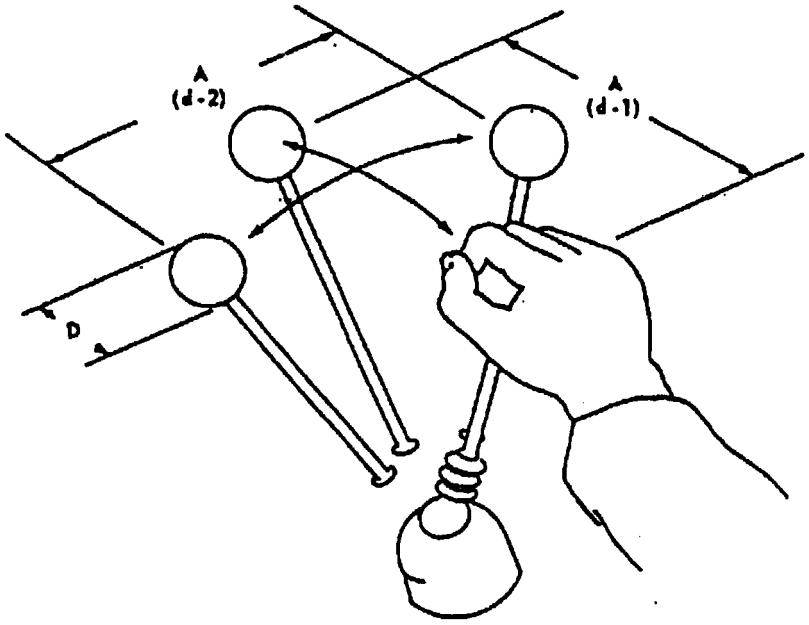
- **6.1.5.14.6 Shape.** The surface of the actuator shall be indented to accept the point of a pen or pencil with the indentation deep enough that the point does not slip as the actuator is manipulated. [Source: MIL-STD-1472F, 1999]

6.1.5.15 Levers

- **6.1.5.15.1 Lever specifications.** The dimensions, resistance, displacement, and separation of levers shall not exceed the maximum and minimum values given in Exhibit 6.1.5.15.1. [Source: MIL-STD-1472F, 1999]

  Note. The dominant hand can supply slightly more force than the nondominant hand, but the difference is not significant. The same amount of push-pull force can be applied when the control is along the median plane of the body as when it is directly in front of the arm, 180 mm (7 in) from the median plane. If the control is placed in front of the opposite (unused) arm, only 75 % as much force can be applied. If the control is 250 to 480 mm (10 to 19 in) forward of the seat reference point, twice as much push-pull force can be applied with two hands as with one-hand operation. Outside this range, two-hand operation becomes less effective. [Source: MIL-STD-1472F, 1999]

Exhibit 6.1.5.15.1 Lever specifications



	Diameter D		Resistance (d - 1)		(d - 2)	
	Finger grasp	Hand grasp	One hand	Two hands	One hand	Two hands
Minimum	13 mm (0.5 in)	38 mm (1.5 in)	9 N (2.0 lb)	9 N (2.0 lb)	9 N (2.0 lb)	9 N (2.0 lb)
Maximum	38 mm (1.5 in)	75 mm (3.0 in)	135 N (30 lb)	220 N (50 lb)	90 N (20 lb)	135 N (30 lb)

	Displacement A		Separation	
	Forward (d - 1)	Lateral (d - 2)	One hand random	Two hands simultaneously
Minimum	--	-- (2.0 in)	50 mm (3.0 in)	75 mm
Preferred	--	-- (4.0 in)	100 mm (5.0 in)	125 mm
Maximum	360 mm (14 in)	970 mm (38 in)	--	--

- **6.1.5.15.2 When to use.** Levers should be used when a large amount of force is needed, or if multidimensional movement of the control is needed. [Source: MIL-STD-1472F, 1999]

- **6.1.5.15.3 Coding.** When several levers are located near one another, the lever handles shall be coded. [Source: MIL-STD-1472F, 1999]

- **6.1.5.15.4 Labeling.** When practicable, all levers shall be labeled with their function and direction of motion. [Source: MIL-STD-1472F, 1999]

- **6.1.5.15.5 Limb support.** When a lever will be used to make fine or continuous adjustments, a support for the appropriate limb shall be provided as follows:

  a. For large hand movements, a support for the elbow.

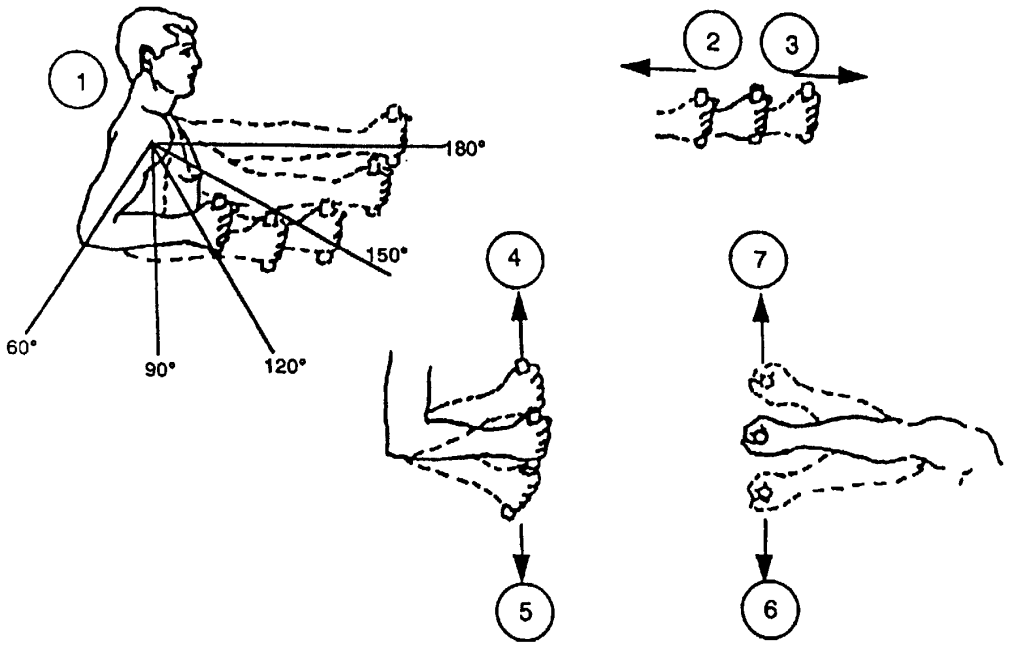
  b. For small hand movements, a support for the forearm.

  c. For finger movements, a support for the wrist. [Source: MIL-STD-1472F, 1999]

6.1.5.16 Hand controls requiring high force

- **6.1.5.16.1 Specifications for males.** Arm, hand, and thumb-finger controls that require high control force shall not exceed the limits given in Exhibit 6.1.5.16.1. The values in the exhibit are for males. [Source: MIL-STD-1472F, 1999]

Exhibit 6.1.5.16.1 Hand-force hand control specifications



Arm strength N (lb)

1	2		3		4		5		6		7	
Degree of elbow flexion	Pull L	Pull R	Push L	Push R	Up L	Up R	Down L	Down R	In L	In R	Out L	Out R
180°	222 (50)	231 (52)	187 (42)	222 (50)	40 (9)	62 (14)	58 (13)	76 (17)	58 (13)	89 (20)	36 (8)	62 (14)
150°	187 (42)	249 (56)	133 (30)	187 (42)	67 (15)	80 (18)	80 (18)	89 (20)	67 (15)	89 (20)	36 (8)	67 (15)
120°	151 (34)	187 (42)	116 (26)	160 (36)	76 (17)	107 (24)	93 (21)	116 (26)	89 (20)	98 (22)	45 (10)	67 (15)
90°	142 (32)	165 (37)	98 (22)	160 (36)	76 (17)	89 (20)	93 (21)	116 (26)	71 (16)	80 (18)	45 (10)	71 (16)
60°	116 (26)	107 (24)	98 (22)	151 (34)	67 (15)	89 (20)	80 (18)	89 (20)	76 (17)	89 (20)	53 (12)	76 (17)

Note. L = Left
R = Right

- **6.1.5.16.2 Specifications for females.** When the control will be used by females, the limits shall be reduced by one-third. [Source: MIL-STD-1472F, 1999]

- **6.1.5.16.3 When not to use.** In general, controls requiring forces greater than the strength limits of the weakest segment of the expected user population, high force controls, and sustained application of high force (that is, durations longer than 3 sec) shall not be used. [Source: MIL-STD-1472F, 1999]

  Exception. High force controls can be used when the user's normal working position provides proper body support, limb support, or both.

6.1.5.17 Miniature controls

- **6.1.5.17.1 Dimensions and separation.** The dimensions and separation of miniature controls shall be the maximum permitted by the available space up to the maximum values specified in this standard for standard-sized controls of the same type. [Source: MIL-STD-1472F, 1999]

- **6.1.5.17.2 Resistance and displacement.** The resistance and displacement of miniature controls should be the same as the resistance and displacement of standard-sized controls of the same type. [Source: MIL-STD-1472F, 1999]

- **6.1.5.17.3 When to use.** Miniature controls shall be used only if severe space limitations exist. [Source: MIL-STD-1472F, 1999]

- **6.1.5.17.4 When not to use.** Miniature controls shall not be used if space is adequate for standard-size controls, and when users are likely to wear gloves or mittens. [Source: MIL-STD-1472F, 1999]

- **6.1.5.17.5 Other requirements.** Other design considerations, such as labeling and orientation, shall conform to those in this standard for standard-size controls of the same type. [Source: MIL-STD-1472F, 1999]

6.2 Visual indicators

6.2.1 General visual indicator information

6.2.1.1 Coding of visual indicators

This section contains general rules for visual coding. Additional specific rules are given in sections pertaining to specific types of visual indicators.

- **6.2.1.1.1 Objectives.** Coding shall be used to facilitate (1) discrimination between individual displays, (2) identification of functionally-related displays, (3) recognition of the relationship between displays, (4) identification of critical information within a display, and to preserve conventional practices and arrangements for warning and alerting systems. [Source: MIL-STD-1472F, 1999]

- **6.2.1.1.2 Visual coding methods.** Visual indicators shall be coded by color, size, location, shape, or flash coding as applicable. [Source: MIL-STD-1472F, 1999]

- **6.2.1.1.3 Consistency.** Visual coding shall be consistent within a system or unit of equipment and between similar units of equipment. [Source: MIL-STD-1472F, 1999]

- **6.2.1.1.4 Visual coding of priority levels.** Visual signals should be coded to indicate the priority level of the signal. [Source: MIL-STD-1472F, 1999]

  Discussion. Acceptable coding methods include color, position, shape, flashing, and symbol. [Source: MIL-STD-1472F, 1999]

- **6.2.1.1.5 Emergency conditions.** Flashing red shall be used to denote emergency conditions that require immediate user action to avert impending injury, equipment damage, or both with an approximately equal on and off time flashing rate from three to five flashes per second. [Source: MIL-STD-1472F, 1999]

- **6.2.1.1.6 Flasher failure.** When an emergency condition exists and the flasher fails, the light shall illuminate and burn steadily. [Source: MIL-STD-1472F, 1999]

- **6.2.1.1.7 Visual tiles.** If visual tiles are used, their legends shall

  a. be concise, specific, and unambiguous;

  b. use abbreviations or acronyms consistent throughout the equipment or system, and

  c. be legible in worst-case conditions, for example, from the far end of the room, or from a spot that maximizes glare. [Source: DOE-HFAC1, 1992]

- **6.2.1.1.8 Singular in purpose.** A visual alarm, with the exception of master caution, warning, and advisory indicators, shall be singular in purpose yet comprehensive in meaning without referring the user to other alarm indicators for other warning information. [Source: DOE-HFAC1, 1992]

6.2.1.2 Analog and digital coding

- **6.2.1.2.1 Analog and digital coding.** Information should be coded in either digital or analog form. [Source: DOE-HFAC1, 1992]

  Discussion. Displays such as meters, plotters, and bar charts on CRTs are examples of analog displays; digital counters and numbers presented on CRTs are examples of digital displays. [Source: DOE-HFAC1, 1992]

- **6.2.1.2.2 When to use digital displays.** Digital displays should be used if there is a need for quick, precise readings of quantitative values and trend information is not needed. [Source: DOE-HFAC1, 1992]

- **6.2.1.2.3 When not to use digital displays.** Digital displays shall not be used if (1) they are the only information displays and perception of a pattern of variation is important or (2) values change so slowly or rapidly that reading them is difficult. [Source: MIL-STD-1472F, 1999]

- **6.2.1.2.4 When to use analog displays.** Analog displays should be used if (1) values need to be considered in relation to ranges or zones or (2) trend information is required. [Source: DOE-HFAC1, 1992]

6.2.2 Transilluminated displays

This section contains rules for transilluminated displays.

Definition. A **transilluminated display** is a display in which light passes through the element being viewed. These displays include panels and indicators that use back- or edge-lighting and that use clear, translucent, fluorescent, or sandwich material. There are three general types of transilluminated displays that are widely used: (1) legend lights that present information in the form of meaningful words, numbers, symbols, and abbreviations, (2) simple indicator lights, and (3) panel assemblies that present qualitative status or system readiness information. [Source: MIL-STD-1472F, 1999]

6.2.2.1 General

- **6.2.2.1.1 When to use.** Transilluminated displays should be used to provide qualitative information that requires immediate attention or an immediate response or to draw attention to important information. [Source: MIL-STD-1472F, 1999]

  Discussion. Transilluminated displays may also be used occasionally for maintenance and adjustment information. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.2 Limited use of lights and illuminated displays.** Lights and illuminated indicators shall be used sparingly, reserved for displaying only that information necessary for effective system operation. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.3 Meaning of illumination.** Lights, including those used in illuminated push buttons, shall indicate equipment response and not simply control position. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.4 Positive feedback.** Changes in display status shall signify changes in functional status, rather than simply a response to control activation. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.5 Meaning of no illumination.** The absence or removal of illumination of a transilluminated display shall not be used to indicate (1) a malfunction, "no-go," or out-of-tolerance condition, (2) a "ready" or in-tolerance condition unless the bulb can be easily tested by the operator or (3) a "power off" condition on a maintenance display. [Source: MIL-STD-1472F, 1999]

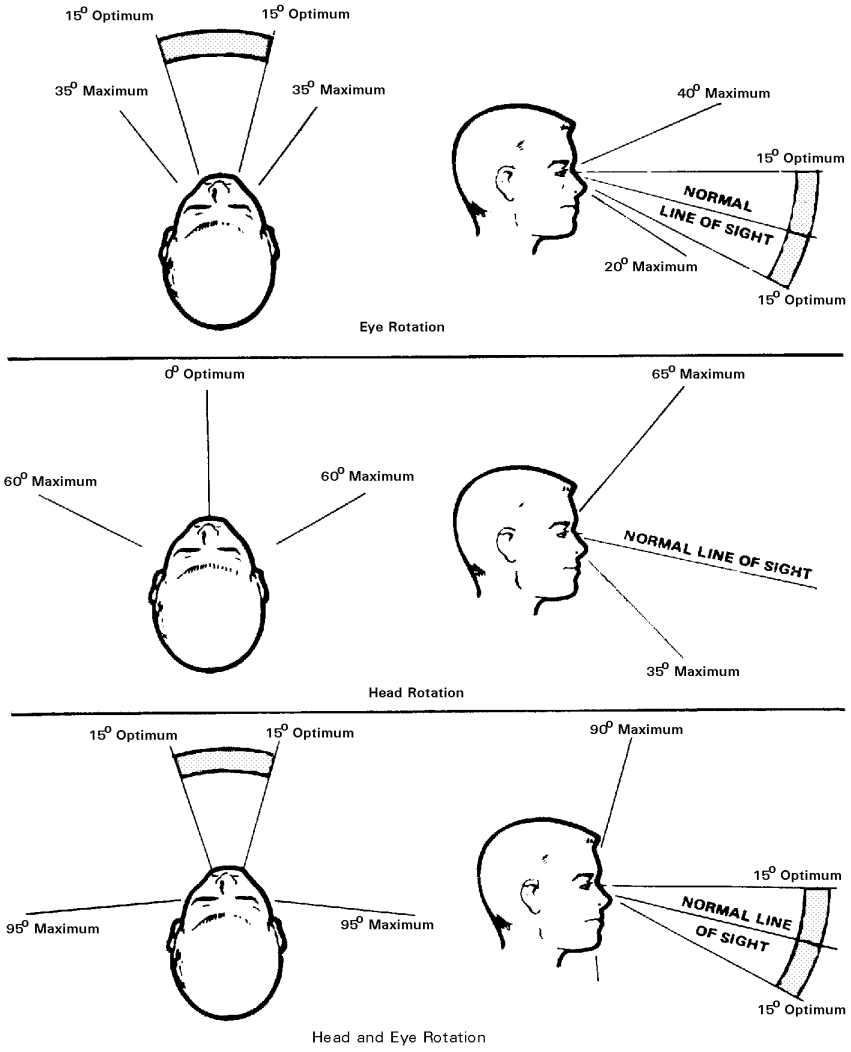
  Discussion. The absence of illumination of a "power on" indicator is acceptable for an operational display. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.6 Grouping of indicator lights.** Master caution lights, master warning lights, master advisory lights, and summation lights used to indicate the condition of an entire subsystem shall be set apart from lights that show the status of subsystem components, except as required in Paragraph 6.2.2.1.8. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.7 Location of transilluminated indicators.** When a transilluminated indicator is associated with a control, it shall be located so that the association of the indicator with the control is unambiguous and so that the light is visible as a user is operating the control. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.8 Location of indicators for critical functions.** Indicators for critical functions shall be located within 15° of the user's normal line of sight, as illustrated in Exhibit 6.2.2.1.8. [Source: MIL-STD-1472F, 1999]

Exhibit 6.2.2.1.8 Optimum vertical and horizontal visual fields.



- **6.2.2.1.9 Location of control device.** The lever, switch, or other control device by which the user takes an action in response to the indicator shall be an integral part of or located as close as possible to the indicator. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.10 Maintenance displays.** Indicator lights used solely for maintenance and adjustment shall be covered or not visible during normal operation of the equipment, but shall be readily accessible when needed. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.11 Luminance.** The luminance of a transilluminated display shall be compatible with the expected ambient illuminance level, and shall be at least 10 %greater than the surrounding luminance. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.12 Glare reduction.** When glare must be reduced, the luminance of the transilluminated display shall not exceed 300 % of the surrounding luminance. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.13 Variable luminance.** When a display will be used in varied ambient illuminance, a dimming control shall be provided with a range of control that permits the display to be legible under the expected range of ambient illuminance. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.14 Dimming in non-critical operations.** Dimming to full OFF may be provided in noncritical operations, but shall not be used if inadvertent failure to turn an indicator ON could lead to a critical maintenance failure, such as the failure to detect or perform a critical step in a maintenance procedure. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.15 False or obscured indication.** Direct or reflected light shall not make indicators appear illuminated when they are not, or appear extinguished when they are illuminated. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.16 Self reflection.** Self-reflection shall be minimized by proper orientation of the display with respect to the observer. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.17 Contrast within an indicator.** The luminance contrast within an indicator shall be at least 2.0. [Source: MIL-STD-1472F, 1999]

  Exception. Special displays specifically designed for legibility in sunlight are exempt from this criterion. [Source: MIL-STD-1472F, 1999]

  Definition. Luminance contrast is the contrast between a figure and its background. Luminance contrast (C) is equal to the difference between the higher luminance value (L_1) and the lower (L_2) divided by the lower value (L_2): $C = (L_1 - L_2)/L_2$.

- **6.2.2.1.18 Low ambient illumination.** When low ambient illumination is expected, the luminance contrast shall be at least 9.0 with the background luminance less than the figure luminance. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.19 Lamp redundancy.** Incandescent lamps used in displays shall be redundant, either through dual filaments or dual lamps. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.20 Indication of lamp replacement.** When one filament or lamp fails, the intensity of the display shall decrease sufficiently to indicate the need for lamp replacement, but not so much that the performance of a user is degraded. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.21 Lamp testing.** When a control panel includes indicator lights using incandescent lamps, it shall also include a means to test the lamps (see Paragraph 6.2.3.5, for exception). When maintenance procedures require dark adaptation, a means for reducing the total brightness of the indicators during testing shall be provided. [Source: MIL-STD-1472F, 1999]

  Discussion. When the panel contains three or fewer lamps, it is preferable that each lamp have its own "press-to-test" control. Otherwise, it is preferable that there be a single control that tests all lamps at the same time. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.22 Maintenance procedures.** When maintenance procedures require dark adaptation, a means for reducing the total brightness of the indicators during testing shall be provided. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.23 Indicator circuit testing.** A means should be provided for testing the operation of indicator circuits. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.24 Removal and replacement of lamps.** Where possible, lamps shall be removable and replaceable through the front of the display panel. Removal and replacement of lamps shall not require the use of tools and shall be accomplished easily and rapidly. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.25 Nonhazardous lamp replacement.** The removal and replacement of lamps while power is applied to the equipment shall not pose a hazard to the user and shall not damage indicator circuit components. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.26 Proper installation of indicator covers.** When the design of indicator covers does not prevent their inadvertent interchange, a means shall be provided for checking the covers after installation to ensure that they are properly installed. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.27 Color-coding.** Color-coding of transilluminated displays shall be in accordance with Exhibit 6.2.2.1.27. [Source: MIL-STD-1472F, 1999]

Exhibit 6.2.2.1.27 Color-coding of transilluminated displays

Color	Use	Examples
flashing red	to indicate an emergency condition that requires immediate action to avert impending injury, equipment damage, or both	
red	to indicate that (1) the system or a portion of the system is inoperative, or (2) successful task completion is not possible until appropriate corrective or override action is taken	"no-go" "error" "failure" "malfunction"
yellow	to indicate (1) a marginal condition, (2) an unexpected delay, (3) that caution is necessary, or (4) that rechecking is necessary	
green	to indicate that (1) equipment is "in tolerance," (2) conditions are satisfactory, or (3) it is all right to proceed	"go ahead" "in tolerance" "ready" "function activated"
white	to indicate system conditions that do not have "right" or "wrong" implications	(1) indicating which of several functions has been selected, (2) indicating a transitory condition such as an action or test in progress, provided such indications have no implications of success or failure
blue	to advise only	

- **6.2.2.1.28 Flashing lights.** The use of flashing lights shall be minimized and used only to call a user's attention to a condition requiring immediate action. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.29 Flash rate.** The flash rate shall be not less than three and not more than five flashes per second, with the on and off times being approximately equal. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.30 Multiple flashing indicators.** When more than one flashing indicator is located within a user's field of view, their flashes shall be synchronized. [Source: MIL-STD-1472F, 1999]

- **6.2.2.1.31 Failed flashing device.** When the indicator is activated but the flashing device has failed, the light shall remain ON. [Source: MIL-STD-1472F, 1999]

6.2.2.2 Legend lights

- **6.2.2.2.1 When to use.** Legend lights shall be used in preference to simple indicator lights except where design considerations demand that simple indicators be used. [Source: MIL-STD-1472F, 1999]

- **6.2.2.2.2 Color-coding.** The color-coding of legend lights shall conform to Exhibit 6.2.2.1.27. [Source: MIL-STD-1472F, 1999]

- **6.2.2.2.3 Size of legend lights.** Legend lights indicating existing or impending hazards (flashing red, red, and yellow) and master summation "go" (green) and "no-go" (red) shall be discriminably larger than other legend lights. [Source: MIL-STD-1472F, 1999]

- **6.2.2.2.4 Illuminated label with opaque background.** An illuminated label and an opaque background shall be used (1) if dark adaptation of the user's eyes is required, (2) if the level of ambient illumination is high, or (3) if needed under other illumination conditions to distinguish control switches from display indicators with similar or identical labels. [Source: MIL-STD-1472F, 1999]

- **6.2.2.2.5 Opaque label with illuminated background.** An opaque label on an illuminated background shall be used: (1) if the indicator is a critical alerting indicator, such as a master warning light, or (2) if dark adaptation is not required. [Source: MIL-STD-1472F, 1999]

- **6.2.2.2.6 Lettering of legends.** The size and other characteristics of the lettering of legends on legend switches shall conform to Section 6.1.2.4. [Source: MIL-STD-1472F, 1999]

- **6.2.2.2.7 Visibility and legibility of legend.** In general, the lettering on single-legend indicators shall be visible and legible whether or not the indicator is illuminated. [Source: MIL-STD-1472F, 1999]

- **6.2.2.2.8 Multi-legend indicators.** Indicators that are capable of presenting more than one legend shall present only one legend at a time, that is, allowing only the legend in use to be visible. [Source: MIL-STD-1472F, 1999]

- **6.2.2.2.9 Stacked legends.** When the indicator "stacks" the different legends, it shall be designed so that it meets the following criteria.

  a. Legends higher in the stack do not obscure legends lower in the stack.

  b. Parallax is minimized.

  c. The brightness and contrast between the legend and background is approximately equal from one legend to another. [Source: MIL-STD-1472F, 1999]

6.2.2.3 Simple indicator lights

- **6.2.2.3.1 When to use.** When design considerations preclude the use of legend lights, simple indicator lights should be used. [Source: MIL-STD-1472F, 1999]

- **6.2.2.3.2 Spacing.** The spacing between adjacent edges of simple round indicator light fixtures shall permit unambiguous labeling, signal interpretation, and convenient lamp removal and replacement. [Source: MIL-STD-1472F, 1999]

- **6.2.2.3.3 Coding.** The coding of simple indicator lights by size and color shall conform to Exhibit 6.2.2.3.3. [Source: MIL-STD-1472F, 1999]

  Discussion. The different sizes shown in Exhibit 6.2.2.3.3 are intended to vary the attention-demanding property of the lights. It is assumed that larger lights are at least equal in luminance to smaller ones. [Source: MIL-STD-1472F, 1999]

Exhibit 6.2.2.3.3 Coding of simple indicator lights

Size/type	Color: Red	Color: Yellow	Color: Green	Color: White
13 mm (0.5 in) diameter or smaller/ steady	Malfunction, action stopped, failure, stop	Delay, check, recheck, acceptable, action	Go ahead, in tolerance, ready	Functional or physical position, action in progress
25 mm (1 in) diameter or larger/steady	Master summation (system or subsystem)	Extreme caution (impending danger)	Master summation (system or subsystem)	
25 mm (1 in) diameter or larger/flashing (3 to 5 per sec)	Emergency condition (impending personnel or equipment disaster)			

6.2.2.4 Transilluminated panel assemblies

- **6.2.2.4.1 When to use.** Transilluminated panel assemblies should be used to

  a. Provide illuminated labels for control panels,

  b. serve as a light source for transilluminated control knobs;

  c. provide illuminated association markings on a control panel, for example, connecting lines between controls, or outlines around a functionally-related group of controls, displays, or both; and

  d. provide a pictorial representation of a system process, communication network, or other information/component organization. [Source: MIL-STD-1472F, 1999]

- **6.2.2.4.2 Large, single, pictorial graphic panels.** Large, single, pictorial graphic panels used to display system processing, communications networks, or other similar applications shall comply with the requirements for visibility, legibility, color, and illumination as specified in this standard. [Source: MIL-STD-1472F, 1999]

- **6.2.2.4.3 Replacing lamps.** When replaceable incandescent lamps are used as the source of illumination for integral lighting of panel assemblies, the lamps shall be readily accessible without disconnecting the panel. [Source: MIL-STD-1472F, 1999]

- **6.2.2.4.4 Sufficient number of lamps.** A sufficient number of lamps shall be provided so that failure of one lamp will not cause any part of the display to be unreadable. [Source: MIL-STD-1472F, 1999]

- **6.2.2.4.5 Brightness.** The brightness of illuminated markings and transilluminated controls shall be compatible with the ambient environment and operating conditions, for example, dark adaptation requirements. [Source: MIL-STD-1472F, 1999]

  Discussion. Provide brightness controls (dimming) as necessary to maintain appropriate visibility and dark adaptation levels.

6.2.3 Dot matrix and segmented displays

- **6.2.3.1 Seven-segment displays.** Seven-segment displays shall only be used to present numeric information. [Source: MIL-STD-1472F, 1999]

  Discussion. Dot matrix, 14-segment, and 16-segment displays may be used for applications involving interactive computer systems, instruments, avionics, navigation, and communication equipment, wherever the presentation of alphanumeric, vector-graphic, symbolic, or real-time information is required. [Source: MIL-STD-1472F, 1999]

- **6.2.3.2 Minimum matrix size.** The smallest matrix for defining a symbol shall be 5 by 7 dots for stationary symbols and 8 by 11 dots for rotating symbols. [Source: MIL-STD-1472F, 1999]

- **6.2.3.3 Preferred matrix size.** The preferred minimum size for a dot matrix shall be 7 by 9 for stationary symbols and 15 by 21 for rotating symbols. [Source: MIL-STD-1472F, 1999]

- **6.2.3.4 Visual angle.** Alphanumeric characters and symbols formed from dot matrixes shall subtend a visual angle of at least 20 min. [Source: MIL-STD-1472F, 1999]

- **6.2.3.5 Viewing angle.** Dot matrix and segmented displays should not be designed for viewing at an angle exceeding 35° from perpendicular to the display. [Source: MIL-STD-1472F, 1999]

- **6.2.3.6 Emitter color.** Monochromatic displays shall use one of these colors in the following order of preference: green (555 nm), yellow (575 nm), orange (585 nm), and red (660 nm) with blue emitters not being used. [Source: MIL-STD-1472F, 1999]

- **6.2.3.7 Intensity control.** Dimming controls shall be provided when applicable to maintain appropriate legibility and a user's dark adaptation level. [Source: MIL-STD-1472F, 1999]

6.2.4 Light emitting diodes

- **6.2.4.1 General.** Light emitting diodes (LEDs) shall conform to the same rules as transilluminated displays. [Source: MIL-STD-1472F, 1999]

- **6.2.4.2 When to use.** LEDs should be used for transilluminated displays, including legend and simple indicator lights, and for matrix (alphanumeric) displays, only if the display is bright enough to be readable in the environment of intended use. [Source: MIL-STD-1472F, 1999]

  Note: The display may be "washed out" at high levels of illumination. [Source: MIL-STD-1472F, 1999]

- **6.2.4.3 Intensity control.** The dimming of LEDs should be proportionate with the dimming of incandescent lamps in the work place. [Source: MIL-STD-1472F, 1999]

- **6.2.4.4 Color-coding for non-red displays.** The color-coding of LEDs other than red alphanumeric displays shall conform to the uses listed in Exhibit 6.2.2.1.27. Red alphanumeric displays shall not be used near red lights that are used in the ways stated in the exhibit. [Source: MIL-STD-1472F, 1999]

- **6.2.4.5 Red alphanumeric displays.** Red alphanumeric displays shall not be used near red lights that are used in the ways stated in the exhibit. [Source: MIL-STD-1472F, 1999]

- **6.2.4.6 Testing.** LED indicator lights having a rating of 100,000 hours mean time between failures shall not require the lamp test capability specified in Paragraph 6.2.2.1.27. [Source: MIL-STD-1472F, 1999]

- **6.2.4.7 Location of red alphanumeric LEDs and segmented displays.** Red LED and segmented displays shall not be grouped with or located adjacent to red warning lights. [Source: MIL-STD-1472F, 1999]

6.2.5 Counters, printers, and flags displays

This section contains rules for direct-reading counters, printers, and flags. Exhibit 6.2.5 lists characteristics and ratings of the goodness of each of these types of display for a variety of uses.

Exhibit 6.2.5 Characteristics and ratings for direct-reading counters, printers, and flags

Use	Counters	Printers	Flags
Quantitative information	**(Good)** Minimum time and error for exact numerical value; however, cannot be read when changing rapidly.	**(Good)** Minimum time and error for exact numerical value. Provides reference records.	Not applicable
Qualitative information	**(Poor)** Numbers must be read. Position changes not easily detected.	**(Poor)** Numbers must be read. Position changes not easily detected.	**(Good)** Easily detected. Economical of space.
Setting	**(Good)** Most accurate monitoring of numerical setting. Relation to motion of setting knob less direct than for moving pointer. Not readable during rapid setting.	Not applicable	Not applicable
Tracking	**(Poor)** No gross position changes to aid monitoring.	Not applicable	Not applicable
General	Most economical of space and illumination. Scale length limited only by number of counter drums.	Limited application.	Limited application.

6.2.5.1 Counters

The rules in this section apply primarily to mechanical counters.

- **6.2.5.1.1 When to use.** Counters should be used to present quantitative data if a quick, precise indication is required and if a continuous trend indication is not required. [Source: MIL-STD-1472F, 1999]

- **6.2.5.1.2 Mounting.** Counters shall be mounted as close as possible to the panel surface to minimize parallax and shadows and to maximize the viewing angle. [Source: MIL-STD-1472F, 1999]

- **6.2.5.1.3 Movement.** The counters shall move in the following ways.

  a. Numbers shall change by snap action rather than by continuous movement.

  b. If an observer is expected to read the numbers consecutively, the numbers shall not change faster than 2 times a second.

  c. Clockwise rotation of the counter reset knob shall increase the counter indication or reset the counter.

  d. Counters that indicate sequencing operations shall reset automatically upon completion of the sequence. Provision shall also be made for manual resetting. If push buttons are used for manual resetting, the force required to operate them shall not exceed 16.7 N (60 oz). [Source: MIL-STD-1472F, 1999]

- **6.2.5.1.4 Illumination.** Counters used in areas in which ambient illumination provides display luminance below 3.5 cd/m^2 (1 fL) shall be self-illuminating. [Source: MIL-STD-1472F, 1999]

- **6.2.5.1.5 Spacing between numerals.** The horizontal separation between numerals shall be between 1/4 and 1/5 the numeral width. Commas shall not be used. [Source: MIL-STD-1472F, 1999]

- **6.2.5.1.6 Finish.** The surface of the counter drums and surrounding areas shall have a dull, matte finish to minimize glare. [Source: MIL-STD-1472F, 1999]

- **6.2.5.1.7 Contrast.** The numerals shall have a high contrast with their background. For example, black on white or white on black. [Source: MIL-STD-1472F, 1999]

6.2.5.2 Flags

- **6.2.5.2.1 When to use.** Flags should be used to display qualitative, nonemergency conditions. See Exhibit 6.2.5 for the characteristics and appropriate uses of flags. [Source: MIL-STD-1472F, 1999]

- **6.2.5.2.2 Mounting.** Flags shall be mounted as close to the surface of the panel as possible without restricting their movement and without obscuring necessary information. [Source: MIL-STD-1472F, 1999]

- **6.2.5.2.3 Snap action.** Flags shall operate with a snap action. [Source: MIL-STD-1472F, 1999]

- **6.2.5.2.4 Contrast.** Luminance contrast between a flag and its background shall be at least 3.0 under all expected lighting conditions. [Source: MIL-STD-1472F, 1999]

- **6.2.5.2.5 Malfunction indication.** When a flag is used to indicate the malfunction of a visual display, the malfunction position of the flag shall obscure part of the user's view of the malfunctioning display and be readily apparent to the user under all expected lighting conditions. [Source: MIL-STD-1472F, 1999]

- **6.2.5.2.6 Legend.** When a legend is provided on a flag, the lettering shall appear upright when the flag assumes the active position. [Source: MIL-STD-1472F, 1999]

- **6.2.5.2.7 Test provision.** A convenient means shall be provided for testing the operation of flags. [Source: MIL-STD-1472F, 1999]

6.2.6 Scale indicators

6.2.6.1 General

There are two general types of scale indicators, those in which the scale is fixed and the pointer moves, and those in which the pointer is fixed and the scale moves. In either case, the scales can be circular, curved (that is, an arc), straight and oriented vertically, or straight and oriented horizontally. Characteristics and ratings of the goodness of each type for a variety of uses are given in Exhibit 6.2.6.1 [Source: MIL-STD-1472F, 1999]

Exhibit 6.2.6.1 Characteristics and ratings of fixed and moveable pointer scales for various uses

	Scales	
Use	**Moving pointer**	**Fixed pointer**
Quantitative information	**(Fair)** May be difficult to read while pointer is in motion.	**(Fair)** May be difficult to read while pointer is in motion.
Qualitative information	**(Good)** Location of pointer easy. Numbers and scale need not be read. Position change easily detected	**(Poor)** Difficult to judge direction and magnitude of deviation without reading numbers and scale
Setting	**(Good)** Simple and direct relation of motion of pointer to motion of setting knob. Position change aids monitoring	**(Fair)** Relation to motion of setting knob may be ambiguous. No pointer position change to aid monitoring. Not readable during rapid setting.
Tracking	**(Good)** Pointer position readily controlled and monitored. Simplest relation to manual control motion.	**(Fair)** No position changes to aid monitoring. Relation to control motion somewhat ambiguous.
General	Requires largest exposed and illuminated area on panel. Scale length limited unless multiple pointers are used.	Saves panel space. Only small section of scale need be exposed and illuminated.

- **6.2.6.1.1 When to use.** Moving-pointer, fixed-scale indicators shall be used rather than fixed-pointer, moving-scale indicators. [Source: MIL-STD-1472F, 1999]

- **6.2.6.1.2 Type of information.** Scale indicators should be used (1) to display quantitative information in combination with qualitative information, for example, trend or direction-of-motion, and (2) if quantitative information is to be displayed and there is no need (such as speed or accuracy) for the use of printers or counters. [Source: MIL-STD-1472F, 1999]

- **6.2.6.1.3 Linear scales.** Linear scales shall be used in preference to nonlinear scales unless system requirements clearly dictate non-linearity to satisfy user information requirements. [Source: MIL-STD-1472F, 1999]

- **6.2.6.1.4 Scale graduations.** Scale graduations shall progress by 1, 2, or 5 units or decimal multiples thereof. [Source: MIL-STD-1472F, 1999]

- **6.2.6.1.5 Intermediate marks.** The number of minor or intermediate marks between numbered scale marks shall not exceed nine. [Source: MIL-STD-1472F, 1999]

- **6.2.6.1.6 Numerals.** Whole numbers shall be used for major graduation marks unless the measurement is normally expressed in decimals. [Source: MIL-STD-1472F, 1999]

- **6.2.6.1.7 Scale starting point.** Display scales shall start at zero unless this is inappropriate for the information displayed. [Source: MIL-STD-1472F, 1999]

- **6.2.6.1.8 Pointer length.** Control and display pointers should extend to, but not overlap, the shortest scale graduation marks. [Source: MIL-STD-1472F, 1999]

- **6.2.6.1.9 Pointer tip.** Each side of the pointer tip should be tapered at a 20° angle (for a total included angle of 40°), terminating in a flat tip equal in width to the width of the minor scale graduations. [Source: MIL-STD-1472F, 1999]

- **6.2.6.1.10 Pointer mounting.** The pointer shall be mounted as close as possible to the face of the dial to minimize parallax. [Source: MIL-STD-1472F, 1999]

- **6.2.6.1.11 Pointer color.** Pointer color from the tip to the center of the dial shall be the same as the color of the marks with the tail of the pointer being the same color as the dial face, unless the tail is used as an indicator itself or unless the pointer is used for horizontal alignment. [Source: MIL-STD-1472F, 1999]

- **6.2.6.1.12 Luminance contrast.** The luminance contrast between the scale face and the markings and between the scale face and the pointer shall be at least 3.0. [Source: MIL-STD-1472F, 1999]

- **6.2.6.1.13 Calibration information.** Provisions shall be made for placing calibration information on instruments without degrading dial legibility. [Source: MIL-STD-1472F, 1999]

- **6.2.6.1.14 Coding.** Coding, for example, by pattern or color, should be used on the face of scale indicators to convey such information as (1) desirable, undesirable, and inefficient operating ranges; (2) dangerous operating levels; and (3) warnings and cautions. [Source: MIL-STD-1472F, 1999]

- **6.2.6.1.15 Pattern or color-coding.** When a given range on a scale indicates a desired operating or other condition, that range shall be made readily identifiable by means of pattern- or color-coding on the face of the indicator. [Source: MIL-STD-1472F, 1999]

- **6.2.6.1.16 Use of colors.** Red, yellow, and green shall be used in accordance with the meanings specified in Exhibit 6.2.2.1.27 and be distinguishable under all expected lighting conditions. [Source: MIL-STD-1472F, 1999]

- **6.2.6.1.17 Pattern coding.** When a scale having ranges will be viewed under low or colored illumination, the ranges should be coded by patterns rather than by color. [Source: MIL-STD-1472F, 1999]

6.2.6.2 Moving-pointer, fixed-scale indicators

- **6.2.6.2.1 Numerical progression.** Numerical values shall increase on fixed scales in the clockwise direction, from left to right and from bottom to top for curved, horizontal, and vertical scales, respectively. [Source: MIL-STD-1472F, 1999]

- **6.2.6.2.2 Orientation.** Numbers on fixed scales shall be oriented in the upright position. [Source: MIL-STD-1472F, 1999]

- **6.2.6.2.3 Scale reading and pointer movement.** The magnitude of a scale reading shall increase as the pointer moves clockwise, up, or to the right. [Source: MIL-STD-1472F, 1999]

- **6.2.6.2.4 Zero position and direction of movement.** When positive and negative values are displayed in opposite directions from a zero or a null position, the magnitude of a positive scale reading shall increase as the pointer moves clockwise, up, or to the right, and the magnitude of a negative reading shall increase as the pointer moves counterclockwise, down, or to the left with the zero or null point located at either the 12 or 9 o'clock position. [Source: MIL-STD-1472F, 1999]

- **6.2.6.2.5 Pointer alignment, circular scales.** When stable values exist for normal operating conditions in a group of circular-scale indicators, the indicators shall be arranged either in rows so that all pointers line up horizontally on the 9 o'clock position under normal operating conditions or in columns so that all pointers line up vertically on the 12 o'clock position under normal operating conditions. [Source: MIL-STD-1472F, 1999]

- **6.2.6.2.6 Indicators arranged in a matrix.** When the indicators are arranged in a matrix, the pointers shall be aligned on the 9 o'clock position rather than the 12 o'clock position. [Source: MIL-STD-1472F, 1999]

- **6.2.6.2.7 Scale break.** Curved scales that do not indicate complete revolutions shall have a break between the two ends of the scale of at least 10°. [Source: MIL-STD-1472F, 1999]

- **6.2.6.2.8 Number of pointers.** When precise readings are required, no more than two coaxial pointers shall be mounted on one indicator face. [Source: MIL-STD-1472F, 1999]

- **6.2.6.2.9 Pointer alignment, noncircular scales.** When stable values exist for normal operating conditions in a group of indicators, vertical scales shall be arranged in rows so that the pointers are aligned horizontally, and horizontal scales arranged in columns so that the pointers are aligned vertically. [Source: MIL-STD-1472F, 1999]

- **6.2.6.2.10 Relative position of scale marks and numbers.** When reading time and accuracy are critical, circular scale markings and location of associated numbers shall be arranged to prevent pointers from covering any portion of the scale marks or numerals. [Source: MIL-STD-1472F, 1999]

  Discussion. If readout accuracy is not critical, that is, if the gross relationship between the pointer and a number is all that is required, the numbers may be placed inside the scale markings, where they are obscured by the pointer when it moves over them. [Source: MIL-STD-1472F, 1999]

- **6.2.6.2.11 Minimize parallax.** Scale marks shall be on or close to the plane of the pointer tip to minimize parallax. [Source: MIL-STD-1472F, 1999]

- **6.2.6.2.12 Placement of pointers.** Pointers shall be located to the right of vertical scales and at the bottom of horizontal scales. [Source: MIL-STD-1472F, 1999]

- **6.2.6.2.13 Placement of numbers.** Numbers shall be placed on the side of graduation marks away from the pointer so that the pointer does not obscure the numbers. [Source: MIL-STD-1472F, 1999]

  Discussion. When the space for circular or curved scales is so limited that the graduations would be difficult to read with this placement, the numbers may be placed inside the graduation marks. [Source: MIL-STD-1472F, 1999]

6.2.6.3 Fixed-pointer moving-scale indicators

- **6.2.6.3.1 When to use.** A fixed-pointer, moving-scale indicator shall be used only when an operation requires it and when it has been approved by the acquisition program office. [Source: MIL-STD-1472F, 1999]

- **6.2.6.3.2 Numerical progression.** On fixed-pointer, moving-scale indicators, numbers shall increase in magnitude in the clockwise direction around the face of a circular or curved dial so that a counter-clockwise movement of the dial results in a higher reading. On vertical or horizontal straight moving scales, numbers shall increase from bottom to top or from left to right. respectively. [Source: MIL-STD-1472F, 1999]

- **6.2.6.3.3 Vertical or horizontal straight moving scales.** On vertical or horizontal straight moving scales, numbers shall increase from bottom to top or from left to right. respectively. [Source: MIL-STD-1472F, 1999]

- **6.2.6.3.4 Orientation.** Numbers on moving scales shall be upright when in the reading position, that is, as they move past the pointer. [Source: MIL-STD-1472F, 1999]

- **6.2.6.3.5 Alignment of pointer or fixed reference line.** For circular scales, the pointer or fixed reference line shall be aligned at the 12 o'clock position for right-left directional information and at the 9 o'clock position for up-down information. [Source: MIL-STD-1472F, 1999]

  Discussion. For purely quantitative information, either position may be used. [Source: MIL-STD-1472F, 1999]

- **6.2.6.3.6 Setting.** When a display will be used for setting a value, for example, tuning a receiver to a specific frequency, the unused portion of the dial face shall be covered, and the open window shall be large enough to permit at least one numbered graduation to appear at each side of any setting. [Source: MIL-STD-1472F, 1999]

- **6.2.6.3.7 Tracking.** When a display will be used for tracking, as in the case of a directional indicator, the whole face of the dial shall be exposed. [Source: MIL-STD-1472F, 1999]

- **6.2.6.3.8 Moving tape displays.** When the length of a scale exceeds the limits of the display and if compression of the scale markings would make the display illegible or subject to errors in reading, a moving tape scale should be used. [Source: MIL-STD-1472F, 1999]

- **6.2.6.3.9 Composite scalar and pictorial displays.** Functionally related information from scales, pointers, and pictorialized symbols is sometimes combined to produce a single display, for example, an artificial horizon or a display that shows both true and relative bearings. The design of these composite displays shall conform to the rules of this section for direction-of-motion, scale-pointer relationships, and legibility. [Source: MIL-STD-1472F, 1999]

6.3 Visual indicator-control integration

This section contains design rules addressing the relationships, groupings, and movement of visual indicators associated with controls.

6.3.1 Basic visual indicator-control relationships

- **6.3.1.1 Relationship.** The relationship of a control to its associated visual indicator and a visual indicator to its associated control shall be immediately apparent and unambiguous to the user. [Source: MIL-STD-1472F, 1999]

  Discussion. Indicator-control relationships can be made apparent through the use of one or more of the following: proximity, grouping, coding, demarcation, labeling, spacing, color-coding, insert panels, and panel relief. [Source: MIL-STD-1472F, 1999]

- **6.3.1.2 No obstruction.** The control itself and the user's hand should not obscure the visual indicator. [Source: MIL-STD-1472F, 1999]

  Discussion. Frequently, controls are located below visual indicators so that both right- and left-handed people are accommodated. [Source: MIL-STD-1472F, 1999]

- **6.3.1.3 Complexity and precision to allow discrimination.** The complexity and precision of visual indicators shall not exceed the ability of the user to discriminate detail. [Source: MIL-STD-1472F, 1999]

- **6.3.1.4 Complexity and precision to allow manipulation.** The complexity and precision of controls shall not exceed the user's manipulative capability, including manual dexterity, coordination, and reaction time, under the dynamic conditions and environment in which his or her performance is expected to occur. [Source: MIL-STD-1472F, 1999]

- **6.3.1.5 Feedback.** A visual indicator associated with a control shall provide rapid feedback that the user perceives it to be instantaneous for any operation of the control. [Source: MIL-STD-1472F, 1999]

- **6.3.1.6 Time lag.** When there is a time lag between control activation and ultimate system state, the system should provide immediate feedback to the user of the process and direction of parameter change. [Source: MIL-STD-1472F, 1999]

- **6.3.1.7 Illumination.** Adjustable illumination shall be provided for all visual indicators and for any labels or markings for visual indicators , controls, and panels that must be read at night or under darkened conditions. [Source: MIL-STD-1472F, 1999]

- **6.3.1.8 Simultaneous access.** When more than one user requires simultaneous access to the same controls and visual indicators, each user shall have the physical and visual access to the controls and visual indicators necessary to perform his or her tasks. [Source: MIL-STD-1472F, 1999]

- **6.3.1.9 Emergency controls and visual indicators.** Emergency controls and visual indicators shall be located where they can be seen and reached quickly and easily. [Source: MIL-STD-1472F, 1999]

6.3.2 Grouping of visual indicator and controls

- **6.3.2.1 Functional grouping.** When functional grouping is used, related controls and visual indicators shall be located near one another and arranged in functional groups, for example, power, status, and test. [Source: MIL-STD-1472F, 1999]

- **6.3.2.2 Sequence.** The controls and visual indicators within a functional group shall be located to provide for left-to-right or top-to-bottom order of use, or both. [Source: MIL-STD-1472F, 1999]

- **6.3.2.3 Arrangement by frequency of use.** Provided that the integrity of grouping by function and sequence is not compromised, the more frequently used and the most important groups should be located in areas of easiest access. [Source: MIL-STD-1472F, 1999]

- **6.3.2.4 Marking functional groups.** A functional group of controls and visual indicators should be indicated by a technique such as enclosing the group with a line marked on the panel or color-coding the group. [Source: MIL-STD-1472F, 1999]

- **6.3.2.5 Consistency.** The location of recurring functional groups and individual items on different panels shall be consistent from panel to panel. [Source: MIL-STD-1472F, 1999]

- **6.3.2.6 Mirror image arrangements.** Mirror image arrangements shall not be used. [Source: MIL-STD-1472F, 1999]

- **6.3.2.7 Location and arrangement.** When large numbers of controls and visual indicators are used, they shall be located and arranged to aid in identifying the controls used with each visual indicator, the equipment component affected by each control, and the equipment component described by each visual indicator. [Source: MIL-STD-1472F, 1999]

- **6.3.2.8 Arrangement within groups.** Controls and visual indicators within functional groups shall be located according to operational sequence, function, or both. [Source: MIL-STD-1472F, 1999]

- **6.3.2.9 Logical flow arrangement.** When there is no unique operational sequence, the controls and visual indicators within a functional group should be arranged in a manner consistent with their logical flow. [Source: MIL-STD-1472F, 1999]

- **6.3.2.10 Arrangement by importance or frequency of use.** When the controls and visual indicators within a functional group are not used in any specific sequence, they should be arranged either in accordance with their importance or their frequency of use. [Source: MIL-STD-1472F, 1999]

- **6.3.2.11 Different arrangement of controls and visual indicators.** When controls are arranged in fewer rows than visual indicators, controls affecting the top row of visual indicators shall be positioned at the far left; controls affecting the second row of visual indicators shall be placed immediately to the right of these, and so on. [Source: MIL-STD-1472F, 1999]

- **6.3.2.12 Vertical and horizontal arrays.** When a horizontal row of visual indicators is associated with a vertical column of controls or vice versa, the farthest left item in the horizontal array shall correspond to the top item in the vertical array. [Source: MIL-STD-1472F, 1999]

  Discussion. Avoid this type of arrangement whenever possible. [Source: MIL-STD-1472F, 1999]

- **6.3.2.13 Simultaneous use.** A visual indicator that is monitored concurrently with manipulation of a related control shall be located so that the user does not have to observe the visual indicator from an extreme visual angle, thus avoiding the possible introduction of errors due to parallax. [Source: MIL-STD-1472F, 1999]

- **6.3.2.14 Multiple visual indicators.** When manipulating one control requires reading several visual indicators, the control shall be placed as near as possible to the related visual indicator and preferably beneath the middle of the visual indicators but not so as to obscure visual indicators when manipulating the control. [Source: MIL-STD-1472F, 1999]

- **6.3.2.15 Combined control.** When more than one visual indicator is affected by a combined control, the visual indicators shall be arranged from left to right with the combined control below the center of the visual indicators, but not so as to obscure the visual indicators when manipulating the control. [Source: MIL-STD-1472F, 1999]

- **6.3.2.16 Visual indicators selected by switches.** When one of a group of visual indicators is selected for viewing with a rotary selector switch, the visual indicators should be arranged so that their sequence corresponds to the switch positions. [Source: NUREG-0700, 1981]

  Example. The top or left-most visual indicator might correspond to switch position one; the next visual indicator down or to the right, to switch position two, and so on. [Source: NUREG-0700, 1981]

- **6.3.2.17 Position of OFF switch.** When the switch includes an OFF position, the OFF position should be to the left of the first active position (that is, it should be the most counter- clockwise position). [Source: NUREG-0700, 1981]

- **6.3.2.18 Non-selected indicators.** Visual indicators that are not selected should read off-scale, not zero. [Source: NUREG-0700, 1981]

- **6.3.2.19 Separated controls and visual indicators.** When controls are located on panels separate from their associated visual indicators , the control and visual indicator panels should be adjacent to each other. [Source: MIL-STD-1472F, 1999]

  Discussion. The preferred arrangement is to place the visual indicator panel above the control panel. [Source: MIL-STD-1472F, 1999]

- **6.3.2.20 Arrangement of separated controls and visual indicators.** When controls and visual indicators are located on separate panels, the arrangement of the controls shall correspond to the arrangement of the associated visual indicators. [Source: MIL-STD-1472F, 1999]

- **6.3.2.21 Correspondence of controls and visual indicators with equipment.** When a group of equipment components have the same function, the arrangement of controls and visual indicators shall correspond to the physical arrangement of their associated equipment components. [Source: MIL-STD-1472F, 1999]

- **6.3.2.22 Alternative techniques.** When none of the preceding rules for arranging controls and visual indicators applies, some other technique, such as color-coding, should be used to indicate the association of controls and visual indicators. [Source: NUREG-0700, 1981]

6.3.3 Movement relationships

- **6.3.3.1 Visual indicator response to control.** The response of a visual indicator to control movements shall be consistent, predictable, and compatible with the user's expectations. [Source: MIL-STD-1472F, 1999]

- **6.3.3.2 Visual indicator response time.** The time lag between system response to a control input and visual indicator presentation of that response shall be minimized, consistent with safe and effective system operation. [Source: MIL-STD-1472F, 1999]

- **6.3.3.3 Moving pointer, circular scale.** Clockwise movement of a rotary control or movement of a linear control forward, up, or to the right shall produce a clockwise movement of circular scale pointers and an increase in the magnitude of the setting. [Source: MIL-STD-1472F, 1999]

- **6.3.3.4 Moving pointer, linear scale.** Clockwise movement of a rotary control or forward, upward, or rightward movement of a linear control shall produce a movement up or to the right for horizontal and vertical scale pointers and an increase in the magnitude of the reading. [Source: MIL-STD-1472F, 1999]

- **6.3.3.5 Digital visual indicators and arrays of indicator lights.** Clockwise movement of a rotary control or movement of a linear control forward, up, or to the right should produce increasing values in digital visual indicators and a bottom-to-top or left-to-right movement in an array of indicator lights. [Source: MIL-STD-1472F, 1999; NUREG-0700, 1981]

- **6.3.3.6 Fixed pointer, moving scale.** Visual indicators with moving scales and fixed pointers or cursors should be avoided. [Source: MIL-STD-1472F, 1999]

- **6.3.3.7 Fixed pointer, moving circular scale.** Clockwise movement of a rotary control or movement of a linear control forward, up, or to the right shall produce a counterclockwise movement of the scale and an increase in the magnitude of the reading. [Source: MIL-STD-1472F, 1999]

- **6.3.3.8 Fixed pointer, moving linear scale.** When use of a vertical or horizontal fixed pointer moving scale indicators is necessary, clockwise movement of a rotary control or movement of a linear control forward, up, or to the right shall produce a movement of the scale down or to the left and an increase in the magnitude of the reading. [Source: MIL-STD-1472F, 1999]

- **6.3.3.9 Direct linkage through an arc greater than 180 degrees.** When a control and visual indicator are directly linked, a rotary control shall be used if the indicator moves through an arc of more than 180 degrees. [Source: MIL-STD-1472F, 1999]

- **6.3.3.10 Direct linkage through an arc less than 180 degrees.** If the indicator moves through an arc of less than 180 degrees, a linear control should be used, provided the path of control movement parallels the average path of the indicator movement and the indicator and control move in the same relative direction. [Source: MIL-STD-1472F, 1999]

- **6.3.3.11 Common plane.** Direction of control movements shall be consistent with related movements of associated visual indicators or equipment components. [Source: MIL-STD-1472F, 1999

- **6.3.3.12 Movement direction.** When a rotary control and a linear display are in the same plane, the part of the control adjacent to the visual indicator shall move in the same direction as the moving part of the visual indicator. [Source: MIL-STD-1472F, 1999]

- **6.3.3.13 Labeling.** When the control-visual indicator relationships specified in this section cannot be followed, controls shall be clearly labeled to indicate the direction of control movement required. [Source: MIL-STD-1472F, 1999]

6.3.4 Visual indicator to control movement ratio

- **6.3.4.1 Minimization of time.** Control/visual indicator ratios for continuous adjustment controls shall minimize the time required to make desired control movements (slewing and fine adjusting), consistent with visual indicator size, tolerance requirements, viewing distance, and time delays. [Source: MIL-STD-1472F, 1999]

- **6.3.4.2 Wide range of visual indicator movement.** When a wide range of visual indicator element movement is required, a small movement of the control shall yield a large movement of the visual indicator element. When a small range of visual indicator movement is required, a large movement of the control shall result in a small movement of the visual indicator, consistent with the final accuracy required. [Source: MIL-STD-1472F, 1999]

- **6.3.4.3 Small range of visual indicator movement.** When a small range of visual indicator movement is required, a large movement of the control shall result in a small movement of the visual indicator, consistent with the final accuracy required. [Source: MIL-STD-1472F, 1999]

- **6.3.4.4 Knob, coarse setting.** When a knob is provided for making coarse display element settings on linear scales— 0.4 to 2.5 mm (0.016 to 0.100 in) tolerance—approximately 150 mm (6 in) visual indicator element movement shall be provided for one complete turn of the knob. [Source: MIL-STD-1472F, 1999]

- **6.3.4.5 Knob, fine setting.** For fine setting on linear scales—0.2 to 0.4 mm (0.008 to 0.016 in) tolerance—25 to 50 mm (1 to 2 in) of visual indicator element movement shall be provided for one complete turn of the knob. [Source: MIL-STD-1472F, 1999]

- **6.3.4.6 Bracketing.** When bracketing is used to locate a maximum or minimum rather than a specific value, the control knob shall swing through an arc of not less than 10° nor more than 30° on either side of the target value in order to make the peak or dip associated with that value clearly noticeable. [Source: MIL-STD-1472F, 1999]

- **6.3.4.7 Lever, coarse setting.** When a lever is provided for coarse settings (0.4 to 2.5 mm (0.016 to 0.100 in) tolerance), one unit of visual indicator element movement shall be induced by three units of lever movement. [Source: MIL-STD-1472F, 1999]

- **6.3.4.8 Counters.** When a counter is provided, one complete revolution of the control shall result in approximately 50 counts, for example, five revolutions of a 10-count drum. [Source: MIL-STD-1472F, 1999]

6.3.5 Failure indicators

- **6.3.5.1. Overload indicators.** When appropriate, an overload indicator shall be provided for each major unit of equipment, component, or circuit, even if it may sometimes be desirable to keep the overloaded item in operation. [Source: National Aeronautics and Space Administration(NASA-STD-3000A), 1989; Department of Defense(MIL-STD-1472D), 1989; Department of Defense(MIL-STD-1800A), 1990]

- **6.3.5.2 Out of range indicators.** When equipment has failed or is not operating within tolerance limits, an indication shall be provided. [Source: NASA-STD-3000A, 1989; MIL-STD-1472D, 1989; MIL-STD-1800A, 1990]

- **6.3.5.3 Power failure indicators.** When a power failure occurs, an indication shall be provided. [Source: MIL-STD-1472D, 1989; NASA-STD-3000A, 1989]

- **6.3.5.4 Open circuit indicators.** When a fuse or circuit breaker has failed, an indication shall be provided. [Source: MIL-STD-1472D, 1989; MIL-STD-1800A, 1990; NASA-STD-3000A, 1989]

- **6.3.5.5 Power-on indicator.** A power-on indicator that extinguishes with loss of power shall be provided. [Source: MIL-STD-1800A, 1990]

6.4 Accommodating people with disabilities

Accessibility in design extends general design principles to cover those individuals who are faced with either temporary or permanent limitations in some dimension of human ability (e.g., sight, hearing, physical mobility, etc.). Although these rules are meant to make systems more accessible and thus make systems available to an increased number of users, it is not possible to design everything for use by everyone. However, there are often adaptations that can significantly increase system accessibility and usefulness. The goal of this section is to make systems more accessible and thus maximize the number of potential users.

Definitions. A **disability** is a physical or mental impairment that substantially limits one or more of a person's major life activities. A **reasonable accommodation** is any modification or adjustment to a job or the work environment that will enable a qualified person with a disability to participate in the application process and to perform essential job functions.

6.4.1 Control accessibility

- **6.4.1.1 Manipulating controls.** Equipment intended to be accessible should be designed to maximize the number of people who can physically operate controls and other input mechanisms. [Source: Vanderheiden & Vanderheiden, 1991]

  Discussion. People who may be unable to operate controls or who can operate them only with difficulty include people with severe weakness, people with missing limbs or digits, people with poor coordination or impaired muscular control, and people with limited movement control. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.2 Minimal force to operate.** Controls intended to be accessible should be designed to minimize the amount of force required to operate a control or provide a means for adjusting the required force. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.3 Ample space between controls.** Controls intended to be accessible should provide ample space between controls for adaptations such as larger knobs or levers. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.4 Alternatives to continuous action.** Equipment meant to be accessible should minimize or provide alternatives to requiring the user to perform continuous action, such as holding a button down. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.5 Alternatives to simultaneous actions.** Equipment meant to be accessible should provide alternatives to requiring simultaneous actions, such as holding down a control key while pressing another key. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.6 Operation with either hand.** Controls should be able to be operated with either the right or the left hand. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.7 Non slip buttons.** Controls should use concave and/or nonslip tops on buttons or provide a ridge around flat keypad buttons. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.8 Alternatives to quick response buttons.** To provide accessibility to more users, controls that normally require a quick response should provide an alternate input method that is not time dependant or the capability of adjusting the required input time interval. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.9 Alternatives to fine motor control.** To provide accessibility to more users, an alternate mechanism that does not require fine motor control should be provided for controls that normally require fine motor control. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.10 Avoid controls that require complex motions.** Controls that require complex motions such as simultaneous twisting and pushing should be avoided. [Source: Vanderheiden & Vanderheiden, 1991; Kanis, 1993]

- **6.4.1.11 Minimize force requirements.** To make controls accessible for users with impaired hand strength, the amount of force necessary to operate controls should be as small as possible. [Source: Kanis, 1993]

- **6.4.1.12 Unobstructed access.** There should be no obstructions that would interfere with a user's ability to manipulate a control. [Source: Kanis, 1993]

- **6.4.1.13 Momentary, not continuous, operation.** A control should not require the user to continuously hold it down in order to activate it unless safety requirements dictate otherwise. [Source: Kanis, 1993]

- **6.4.1.14 Unconstrained manipulation.** To allow accessibility for users with impaired hand strength, a control should be designed to permit users great flexibility in how the control is manipulated, whether by using the fingers, the full hand, or both hands. [Source: Kanis, 1993]

- **6.4.1.15 Reaching controls.** Controls and input devices on equipment intended to be accessible should be located within easy reach of intended users, including short people and people who have limited reach, such as those in wheelchairs. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.16 Arrange by frequency of use.** Controls that must be used frequently should be placed in positions that are the most easily reached with the minimum change of body position and where wrist or arm support is available. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.17 Alternative activation for unreachable controls.** To make controls that are unreachable to some users accessible, alternative mans of operations such as a redundant speech input option or remote control should be provided. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.18 Identifying controls without sight.** Equipment intended to be accessible to the visually impaired should be designed to maximize the number of people who can find and identify individual controls even if they cannot see them. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.19 Nonvisual means for identifying controls.** Equipment intended to be accessible to the visually impaired should provide a nonvisual means for differentiating controls such as by correlating size, shape, or texture with importance or function. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.20 Sufficient space for labeling.** Equipment intended to be accessible to the visually impaired should provide adequate space for tactile localization and identification and labeling with large print or Braille. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.21 Controls near controlled objects**. Controls should be located close to the objects they control. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.22 Logical layout of controls**. Controls should be arranged in a manner that is logical and easy to understand. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.23 Provide ridges on flat control buttons**. Flat panel buttons should provide a ridge or raised lip around the buttons. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.24 Alternative input options**. Controls that are not accessible to the visually impaired should provide an alternative means of manipulation such as a redundant speech recognition input option for the visually impaired user. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.26 Reading control labels.** Equipment intended to be accessible should be designed to maximize the number of people who can read the labels on controls. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.27 Large lettering on labels.** The lettering of labels on equipment intended to be accessible should be as large as practical. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.28 Labels readable from wheelchair.** Important labels on equipment intended to be accessible should be placed where they can be read by short people or people in wheelchairs. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.29 Alternative labeling for visually impaired.** Stick on tactile labels or large print labels should be made available as options for equipment intended to be accessible to the visually impaired. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.30 Avoid the use of blue, green and violet coding.** Systems that will be used by aging users should avoid the use of blue, green and violet coding. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.31 Group controls.** Controls should be arranged in groups that facilitate tactile identification. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.32 Determining control status.** Equipment intended to be accessible to the visually impaired should be designed to maximize the number of people who can determine the status or setting of controls through nonvisual means. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.33 Multi-sensory indication of status.** Controls meant to be accessible to visually impaired users should provide multi-sensory indications of control status (positions or levels). [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.34 Use knobs with pointers.** Knobs intended for use by the visually impaired should have highly visible raised pointers with a tactile orientation cue. [Source: Vanderheiden & Vanderheiden, 1991]

- **6.4.1.35 Moving pointers and stationary scales.** Controls intended to be accessible should use moving pointers and stationary scales rather than moving scales and stationary pointers. [Source: Vanderheiden & Vanderheiden, 1991]

Glossary

Disability - A disability is a physical or mental impairment that substantially limits one or more of a person's major life activities.

Levers - Levers are controls having the same size and shape, but that allow continuous adjustment.

Luminance contrast - Luminance contrast is the contrast between a figure and its background.

Reasonable accommodation - Reasonable accommodation is any modification or adjustment to a job or the work environment that will enable a qualified person with a disability to participate in the application process and to perform essential job functions.

Toggle switch - A toggle switch is a switch with discrete positions operated by a lever.

Transilluminated display - A transilluminated display is a display in which light passes through the element being viewed.

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